PATENT ABSTRACTS OF JAPAN

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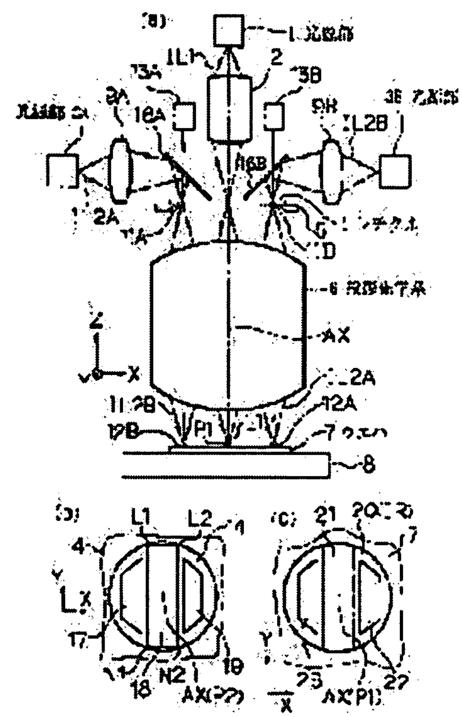
(54) PROJECTION ALIGNER

(57)Abstract:

PROBLEM TO BE SOLVED: To reduce the abberation variation in a projection optical system, when the pattern of a rotationally asymmetric area on a reticle is transferred to a wafer through the projection optical system.



SOLUTION: Light source sections 3A and 3B, which emit illuminating light rays IL2A and IL2B having such waveforms that do not sensitize a photoresist on a wafer, are provided separately from a light source section 1 for exposure. A rectangular area 18 on a reticle 4 is irradiated with the illuminating light IL1 from the light source section areas 17 and 19 on both sides of the area 18 on the reticle 4 are irradiated with the illuminating light rays IL2A and IL2B from the light source sections 3A and 3B. Therefore, the deviation of the distribution of irradiating energy made incident to the lens of a projection optical system 6 is reduced, and the aberration variation of the optical system PL due to the rotationally asymmetric thermal deformation, etc., of the lens becomes smaller. The light rays IL2a and IL2B can also be utilized as the illuminating light rays of alignment sensors 13A and 13B.

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* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] The predetermined pattern for an imprint formed in the mask is set in a predetermined circular exposure field symmetrical with rotation to the 1st point that the projection optics projected on a photosensitive substrate, and the optical axis of said projection optics and the exposed field of said photosensitive substrate cross. said 1st point -- receiving -- rotation -- an unsymmetrical exposure lighting field -- forming -- rotation, in order to imprint an unsymmetrical mask pattern image on said photosensitive substrate the 2nd point that supply the 1st illumination light with the wavelength which exposes said photosensitive substrate, and the optical axis of said projection optics and the pattern side of said mask cross -- receiving -- the inside of the pattern side of said mask -- rotation -- with the 1st illumination system which forms an unsymmetrical exposure lighting field the 2nd illumination light which has nonphotosensitivity wavelength towards said photosensitive substrate through said projection optics -- supplying -- said 1st illumination light -- following -- the inside of said predetermined circular exposure field -- so that the whole may be illuminated mostly said rotation in the exposed field of said photosensitive substrate -- the projection aligner characterized by having the 2nd illumination system which forms the non-exposing lighting field which complements an unsymmetrical exposure lighting field in said predetermined circular exposure field.
[Claim 2] The projection optics which projects the predetermined pattern for an imprint formed in the mask on a photosensitive substrate, The 1st light source section which supplies the 1st illumination light with the wavelength which exposes said photosensitive substrate, On the optical path between the synthetic system which compounds the 2nd light source section which supplies the 2nd illumination light which has nonphotosensitivity wavelength to said photosensitive substrate, and said 1st illumination light and said 2nd illumination light, and is led to said mask, and this synthetic system and said mask The field diaphragm arranged in the location which serves as conjugate substantially with the pattern side of said mask is prepared. Said field diaphragm It has the 1st transparency section which makes said 1st illumination light penetrate, and the 2nd transparency section which makes said 2nd illumination light penetrate. Said 1st transparency section It sets in a predetermined circular field symmetrical with rotation to the predetermined point that the optical axis of said projection optics and the pattern side of said mask cross. They are the 1st field as an unsymmetrical exposure lighting field, and conjugation. said predetermined point -- receiving -- rotation -- said 2nd transparency field the inside of a predetermined circular field symmetrical with said rotation by being accompanied by said 1st illumination light -- the whole is illuminated mostly -- as -- said rotation -- the projection aligner characterized by being the 2nd field as an exposed lighting field and conjugation which complement the 1st unsymmetrical field.
[Claim 3] The projection aligner characterized by to have the mark location detection system which detects in photoelectricity the light from at least one side of the mask mark on said mask which is a projection aligner claim 1 or given in two, and is located in the field which said 2nd illumination light illuminates, and the substrate mark on said photosensitive substrate located in the field which said 2nd illumination light illuminates, and detects the location of one [at least] mark of both marks.

[Claim 4] It is the projection aligner [claim 5] characterized by being a projection aligner claims 1 and 2 or given in three, and a predetermined circular exposure field symmetrical with said rotation, or a predetermined circular field symmetrical with said rotation and the field on said photosensitive substrate [****] being in agreement with the visual field by the side of said photosensitive substrate of said projection optics. The projection optics which projects the predetermined pattern for an imprint formed in the mask on a photosensitive substrate, The illumination-light study system which illuminates said mask by the illumination light with the wavelength which exposes said photosensitive substrate, Said illumination light which has been arranged between said projection optics and said photosensitive substrates, prepared the optical limit member with the predetermined light transmission section, and passed the light transmission section of this optical limit member the predetermined point that the optical axis of said projection optics and the exposed field of said photosensitive substrate cross -- receiving -- the inside of a predetermined circular exposure field symmetrical with rotation -- setting -- said predetermined point -- receiving -- rotation -- the projection aligner characterized by carrying out incidence to an unsymmetrical field.

[Translation done.]

* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention For example, a semiconductor device, a liquid crystal display component, an image sensor (CCD etc.), Or it is related with the projection aligner used in order to expose the pattern on a mask on a photosensitive substrate at the photolithography process for manufacturing the thin film magnetic head etc. rotation especially like the shape of a slit in the pattern for the imprint on a mask -- the pattern of an unsymmetrical field in the condition of having projected on the substrate A mask and a substrate are applied to the projection aligner of scan exposure molds, such as step - exposed by carrying out a synchronous scan to projection optics, and - scanning method, and it is suitable.
[0002]
[Description of the Prior Art] In order to manufacture a semiconductor device etc. conventionally, the projection aligner of one-shot exposure molds, such as a stepper who exposes on the wafers (or glass plate etc.) on the reticles (or photo mask etc.) as a mask with which the pattern in a square-like lighting field was mostly applied to the photoresist as a photosensitive substrate through projection optics, has been used abundantly. On the other hand, since it corresponds to enlargement of chip patterns, such as a semiconductor device, recently, imprinting the pattern of the reticle of a bigger area to each shot field on a wafer is called for. However, the design and manufacture of projection optics which controlled aberration, such as distortion and a curvature of field, below to the predetermined allowed value all over the large effective exposure field (visual field) are difficult.
[0003] Therefore, recently, the projection aligner of scan exposure molds, such as step - which exposes the pattern of a reticle serially to each shot field on a wafer, and - scanning method, attracts attention, carrying out the synchronous scan of a reticle and the wafer to projection optics, where the pattern in the lighting field of the shape of the rectangle on a reticle or a slit of circular ** is projected on a wafer through projection optics. It can make the most of the diameter of the effective exposure field of projection optics, and also since this scan exposure type of projection aligner can do the die length of the imprint pattern to a scanning direction for a long time than the diameter of that effective exposure field, it can imprint the pattern of the reticle of a large area on a wafer by small aberration as a result.
[0004]
[Problem(s) to be Solved by the Invention] Generally in a projection aligner, the illumination light which has high energy to the lens of projection optics is irradiated on the occasion of exposure. Therefore, when the illumination light is irradiated in the condition with rotation asymmetry about an optical axis on a lens, and the temperature distribution of a lens change with the heat of absorption of exposure energy, refractive-index distribution of ** material is changed [even if the absorption coefficient of the exposure energy of the ** material which constitutes the lens of projection optics is about 0.2%/cm slightly,] to rotation asymmetry by the temperature rise with a lens partial in carrying out heat deformation to rotation asymmetry. Aberration fluctuation of the projection optics by the exposure of the illumination light of uneven illumination distribution which has rotation asymmetry

which this says that the aberration of projection optics gets worse gradually arises. Such aberration fluctuation has been in the condition that it cannot admit, under the conditions as which a high resolution and high exposure precision like today is required.

[0005] Conventionally, to fluctuation of the aberration of such projection optics, it has been coped with by controlling the pressure of the gas which divides projection optics into three blocks, seals each block, and touches the lens within each block. By this approach, in the case of the one-shot exposure mold which uses a square lighting field mostly, since extent of rotation asymmetry of that lighting field is low, aberration fluctuation has fully been amended. as [say / however, / like the projection aligner of a scan exposure mold / that the lighting field on a reticle is made into the shape of a rectangle or a slit of circular **] -- remarkable -- an optical axis -- being related -- rotation -- when using an unsymmetrical lighting field, even if it performed such atmospheric-pressure control, a possibility that fluctuation of aberration, such as distortion and a curvature of field, might not be settled within an allowed value came out. When especially rotation asymmetry is remarkable, there is also un-arranging [that the astigmatism that the best image surface of the pattern of the meridional direction and the best image surface of the pattern of a direction perpendicular to it separate in the direction of an optical axis at the core of the exposure field of projection optics arises].

[0006] this invention -- this point -- taking an example -- the rotation on a reticle -- when imprinting the pattern of an unsymmetrical field on a wafer through projection optics, it aims at offering a projection aligner with little aberration fluctuation of projection optics.

[0007]

[Means for Solving the Problem] The 1st projection aligner by this invention For example, the projection optics which projects the predetermined pattern for an imprint formed in the mask (4) on a photosensitive substrate (7) as shown in drawing 1 (6), It sets in a predetermined circular exposure field (20) symmetrical with rotation to the 1st point (P1) that the optical axis (AX) and the exposed field of a photosensitive substrate (7) of the projection optics cross. the 1st point (P1) -- receiving -- rotation -- an unsymmetrical exposure lighting field (21) -- forming -- rotation, in order to imprint an unsymmetrical mask pattern image on the photosensitive substrate (7) The 1st illumination light (IL1) with the wavelength which exposes the photosensitive substrate (7) is supplied. the 2nd point (P2) that the optical axis and the pattern side of a mask (4) of the projection optics (6) cross -- receiving -- the inside of the pattern side of the mask (4) -- rotation -- with the 1st illumination system (1 2) which forms an unsymmetrical exposure lighting field (18) The 2nd illumination light (IL2A, IL2B) which has nonphotosensitivity wavelength towards the photosensitive substrate (7) through the projection optics (6) is supplied. the 1st illumination light (IL1) -- following -- the inside of the predetermined circular exposure field (20) -- so that the whole may be illuminated mostly the rotation in the exposed field of the photosensitive substrate (7) -- it has the 2nd illumination system (3A, 3B, 9A, 9B, 16A, 16B) which forms the non-exposing lighting field (22 23) which complements an unsymmetrical exposure lighting field (21) in the predetermined circular exposure field (20).

[0008] In this case, a certain extent needs to be absorbed by the ** material of the lens with which that 2nd illumination light (IL2A, IL2B) constitutes projection optics (6). However, it may be absorbed by the coating film of a lens instead of being absorbed by the ** material of a lens. According to the 1st projection aligner of this this invention, irradiate on a photosensitive substrate (7) like [the 2nd illumination light (IL2A, IL2B)] the 1st illumination light (IL1), but Since the 2nd illumination light (IL2A, IL2B) is nonphotosensitivity to a photosensitive substrate (7), the rotation on the mask (4) illuminated by the 1st illumination light (IL1) -- the image of the pattern of an unsymmetrical exposure lighting field (18) -- the rotation on a photosensitive substrate (7) -- an unsymmetrical exposure lighting field (21) imprints. moreover, the rotation on a photosensitive substrate (7) -- in order to illuminate the exposed field (22 23) which complements an unsymmetrical exposure lighting field (21) and forms a circular exposure field (20) symmetrical with rotation by the 2nd illumination light (IL2A, IL2B), the symmetry-of-revolution nature of the exposure energy distribution to the lens of projection optics (6) increases it. therefore, rotation of the lens of projection optics (6) -- unsymmetrical heat deformation -- decreasing -- rotation -- in order that unsymmetrical refractive-index distribution may also decrease,

fluctuation of the aberration of projection optics (6) decreases.
[0009] Moreover, as the 2nd projection aligner by this invention is shown in drawing 2 The projection optics which projects the predetermined pattern for an imprint formed in the mask (4) on a photosensitive substrate (7) (6), The 1st light source section which supplies the 1st illumination light (IL1) with the wavelength which exposes the photosensitive substrate (7) (1 41), The 2nd light source section which supplies the 2nd illumination light (IL2A) which has nonphotosensitivity wavelength to the photosensitive substrate (7) (3A, 47), On the optical path between the synthetic system (42, 44, 46) which compounds that 1st illumination light (IL1) and its 2nd illumination light (IL2A), and is led to that mask (4), this synthetic system, and its mask (4) The field diaphragm (48) arranged in the location which serves as conjugate substantially with the pattern side of the mask (4) is prepared. The field diaphragm (48) It has the 1st transparency section (50) which makes the 1st illumination light (IL1) penetrate, and the 2nd transparency section (49 51) which makes the 2nd illumination light (IL2A) penetrate. The 1st transparency section (50) It sets in a predetermined circular field (48) symmetrical with rotation to the predetermined point that the optical axis (AX) and the pattern side of a mask (4) of the projection optics (6) cross. They are the 1st field (50) as an unsymmetrical exposure lighting field, and conjugation. the predetermined point -- receiving -- rotation -- the 2nd transparency field (49 51) the inside of a predetermined circular field (48) symmetrical with the rotation by being accompanied by the 1st illumination light (IL1) -- the whole is illuminated mostly -- as -- the rotation -- it is the 2nd field (49 51) as an exposed lighting field and conjugation which complement the 1st unsymmetrical field (50).
[0010] According to the 2nd projection aligner of this this invention, the 1st and 2nd illumination light (IL1, IL2A) once compounded by the synthetic system (42, 44, 46) by the field diaphragm (48) the rotation on a mask (4) -- an unsymmetrical exposed lighting field (50) and its rotation -- pass through a field the exposed lighting field (49 51) which complements an unsymmetrical exposed lighting field, and pass projection optics (6) -- it irradiates on a photosensitive substrate (7). in this case, the 1st illumination light (IL1) -- a field diaphragm (48) -- rotation of a mask (4) -- in order to pass the 1st field (50) as an unsymmetrical exposed lighting field, and the 1st transparency section [****] (50), on a photosensitive substrate (7), only the image of the pattern of that 1st field (50) on that mask (4) is imprinted.
[0011] On the other hand, the 1st illumination light (IL1) which penetrates the 1st field (50) on a mask (4), and the 2nd illumination light (IL2A) which penetrates the 2nd field (49 51) on the mask (4) which complements the 1st field and forms a circular field (48) symmetrical with rotation substantially carry out incidence to projection optics (6). Since the exposure field of the 1st and 2nd whole illumination light (IL1, IL2A) turns into a circular field symmetrical with rotation substantially, the symmetry-of-revolution nature of the exposure energy distribution to the lens of projection optics (6) increases it like the 1st projection aligner of this invention. Therefore, aberration fluctuation of projection optics (6) decreases. Moreover, in this invention, the optical system for specifying the visual field on rotation the optical system for specifying the visual field of the 1st illumination light (IL1) irradiated by the unsymmetrical exposed lighting field and the mask (4) of the 2nd illumination light (IL2A) on a mask (4) becomes unnecessary.
[0012] Moreover, it sets to the 1st and 2nd projection aligners of this invention. The light from at least one side of the mask mark (11A, 11B) on the mask (4) located in the field which the 2nd illumination light (IL2A) illuminates, and the substrate mark (12A, 12B) on the photosensitive substrate (7) located in the field which the 2nd illumination light (IL2A) illuminates It is desirable to have the mark location detection system (13A, 13B) which detects in photoelectricity and detects the location of one [at least] mark of both marks. Thereby, the 2nd illumination light (IL2A) can be effectively used as illumination light for the mark location detection systems (13A, 13B) for detecting the location of a mask (4) or a photosensitive substrate (7).
[0013] Moreover, as for a predetermined circular exposure field (20) symmetrical with the rotation, or a predetermined circular field (48) symmetrical with the rotation and the field on the photosensitive substrate [****] (7), it is desirable that it is in agreement with the visual field by the side of the photosensitive substrate (7) of the projection optics (6). Thereby, since the lens of projection optics (6)

is mostly illuminated by the circular lighting field of an overall diameter by the symmetry of revolution, distribution of the exposure energy to a lens becomes the symmetry of revolution further.
[0014] Moreover, as the 3rd projection aligner by this invention is shown in drawing 8 The projection optics which projects the predetermined pattern for an imprint formed in the mask (4) on a photosensitive substrate (7) (6), The illumination-light study system which illuminates the mask (4) by the illumination light (IL1) with the wavelength which exposes the photosensitive substrate (7) (1A, 41), The optical limit member which is arranged between the projection optics (6) and its photosensitive substrate (7), and has the predetermined light transmission section (73) (71), That illumination light (IL1) that passed the light transmission section (73) of ****** and this optical limit member the predetermined point that the optical axis (AX) and the exposed field of a photosensitive substrate (7) of the projection optics (6) cross -- receiving -- the inside of a predetermined circular exposure field (71) symmetrical with rotation -- setting -- the predetermined point -- receiving -- rotation -- incidence is carried out to an unsymmetrical field (73).
[0015] the light limit member (71) after the photosensitive illumination light (IL1) passes through a mask (4) and a field symmetrical with rotation of projection optics (6) to a photosensitive substrate (6) according to the 3rd projection aligner of this this invention -- the rotation on a mask (4) -- it passes only through the field corresponding to an unsymmetrical field, and irradiates on a photosensitive substrate (7). therefore, the rotation on a mask (4) -- only the image of the unsymmetrical pattern of a field is imprinted on a photosensitive substrate (7). Moreover, in order to illuminate a field symmetrical with the rotation on a mask (4) by the illumination light (IL1), like the 1st and 2nd projection aligners of this invention, the symmetry-of-revolution nature of the exposure energy distribution to the lens of projection optics (6) increases, and aberration fluctuation of projection optics (6) decreases. Especially in this invention, in order to illuminate a mask (4) only by one illumination light (IL1), the light energy of uniform wavelength is irradiated by the whole lens of projection optics (6). therefore, the absorbed amount of the heat energy in these lenses -- uniform -- becoming -- rotation of a lens -- unsymmetrical heat deformation decreases further and generating of the aberration of projection optics (6) is also suppressed further. Moreover, since only one illumination light (IL1) is used, a facility of the light source, an illumination-light study system, etc. can be saved.
[0016]
[Embodiment of the Invention] Hereafter, with reference to drawing 1 , it explains per 1st example of the gestalt of operation of the projection aligner of this invention. This example applies this invention to the projection aligner of step - and - scanning method. As drawing 1 (a) shows the outline configuration of the projection aligner of this example and shows it to this drawing 1 (a), the three light source sections 1, 3A, and 3B which illuminate the pattern space on a reticle 4 are formed in this example. At the time of exposure, from the light source section 1, the illumination light IL 1 of the photosensitive wavelength lambda 1 is injected by the photoresist applied on the wafer 7, and illumination-light IL2A of the nonphotosensitivity wavelength lambda 2 and IL2B are injected by the photoresist of a wafer 7 from the light source sections 3A and 3B. The light source section 1 is constituted including the field diaphragm which specifies the fly eye lens for making illuminance distribution on the exposure light source and a reticle 4 into homogeneity, and the lighting field on a reticle 4, and the illumination light IL 1 injected from the light source section 1 is irradiated through the illumination-light study system 2 by the non-scanning direction on a reticle 4 to the lighting field 18 (refer to drawing 1 (b)) of a long rectangle. It imprints for the projection scale factor beta (beta is 1/4, or 1 / 5 grades) on the wafer 7 with which the photoresist was applied for the image of the pattern in the lighting field 18 of the rectangle of a reticle 4 through projection optics 6 under the illumination light IL 1. The Z-axis is taken in parallel with the optical axis AX of projection optics 6 hereafter, and a Y-axis is taken and explained to the space of drawing 1 (a) in a two-dimensional flat surface perpendicular to the Z-axis at right angles to the space of the X-axis and drawing 1 (a) in parallel. In this example, the reticle 4 at the time of scan exposure and the scanning direction of a wafer 7 are the directions of X.
[0017] On the other hand, the light source sections 3A and 3B of a non-exposing light are constituted including the field diaphragm which specifies the fly eye lens for making illuminance distribution on the

light source and a reticle 4 into homogeneity, respectively, and the lighting field on a reticle 4. And condensing lens 9A is penetrated, it is caudad reflected by mirror 16A which has the slight transmission installed to the direction of incidence of illumination-light IL2A, and illumination-light IL2A of wavelength lambda 2 injected from light source section 3A arranged in the upper part of the direction of -X of a reticle 4 is condensed by the lighting field 17 (refer to drawing 1 (b)) on a reticle 4. Moreover, condensing lens 9B is penetrated, it is caudad reflected by mirror 16B which has the slight transmission installed to the direction of incidence of illumination-light IL2B, and illumination-light IL2B of wavelength lambda 2 injected from light source section 3B arranged in the upper part of the direction of +X of a reticle 4 is condensed by the lighting field 19 on a reticle 4. And illumination-light IL2A which penetrated the reticle 4, and IL2B are irradiated on a wafer 7 through projection optics 6.

[0018] In this case, the lighting field 17 of illumination-light IL2A and the lighting field 19 of illumination-light IL2B are set up so that it may become a scanning direction to an outside field to the lighting field 18 of the rectangle on the reticle 4 of the illumination light IL 1, respectively. Although the wavelength lambda 2 of the wavelength lambda 1 of the illumination light IL 1 and illumination-light IL2A, and IL2B changes with the class of photoresist, and classes of ** material of projection optics 6, in the usual case, wavelength lambda 1 chooses less than 530nm, and wavelength lambda 2 chooses the wavelength of 530nm or more. As illumination light IL 1 for exposure, the higher harmonic of excimer laser light, such as the bright lines, such as i line (wavelength of 365nm) and g line (wavelength of 436nm), ArF excimer laser light (wavelength of 193nm), and KrF excimer laser light (wavelength of 248nm), or the copper steamy laser beam of a mercury lamp, or YAG laser light etc. is used.

[0019] moreover, rotation of as opposed to the ** material of projection optics 6 in illumination-light IL2A and IL2B -- since it is used in order to suppress distribution of unsymmetrical exposure energy, the thing near the illumination light IL 1 as a whole has the desirable amount of light absorption per unit area in ** material or the coating film of a lens. It is the wavelength which does not expose a photoresist as illumination-light IL2A and an IL2B from the semantics, when the rate of the absorption of light is small, the optical reinforcement of the light source is strong, and what, on the other hand, has the biggest possible wavelength of the rate of light absorption to the ** material or coating film of a lens of projection optics 6 when the optical reinforcement of the light source is small is desirable. As a desirable example, the laser beam (wavelength of 633nm) from helium-Ne laser etc. is mentioned, for example.

[0020] In addition, as ** material of projection optics, when a quartz, glass, etc. are used, since long wave length about 2 micrometers or more also has a remarkable rate of light absorption, these ** material may use HF chemical laser light (wavelength of 2.4-3.4 micrometers) using the chemical reaction of hydrogen fluoride (HF) gas etc. as illumination-light IL2A and an IL2B. moreover -- the illumination light in which long wave length 530nm or more also has some which have a rate of light absorption near [cm] in 1% /, and has such a rate of light absorption near [cm] in 1% /since optical glass other than a quartz contains the impurity -- rotation of exposure energy -- as a cure of unsymmetrical distribution, it is effective enough. As an example of such illumination light, C line (wavelength of 656.3nm) from the hydrogen (H2) discharge tube, d line (wavelength of 587.6nm) from the helium (helium) discharge tube, etc. are mentioned.

[0021] Next, the reticle 4 is laid on the reticle stage [move / and / with constant speed / to a scanning direction (the direction of X) / it / freely] 5 which can be moved slightly in the direction of X, and the direction of Y. The location of a reticle stage 5 is measured by the precision with the external laser interferometer (un-illustrating), and the location of a reticle stage 5 is controlled based on the measured value of the laser interferometer. Moreover, on the reticle 4, the reticle marks 11A and 11B for alignment with a wafer 7 are formed.

[0022] On the other hand, the wafer 7 is laid through the non-illustrated wafer holder on the wafer stage 8 freely movable to a scanning direction (the direction of X) with constant speed. The wafer stage 8 is constituted so that stepping migration can also be performed in the direction of X, and the direction of Y, and the image of the pattern of a reticle 4 is serially imprinted by each shot field on a wafer 7 according to step - and - scanning method which repeat the actuation which moves each shot field on a wafer 7 to the scan starting position to the exposure field of projection optics 6, and scan exposure

actuation. At the time of scan exposure, a reticle 4 is for example, the rate VR to the direction of +X (or the direction of -X). It synchronizes with being scanned and a wafer 7 is rate beta-VR to the direction of -X (or the direction of +X). (beta is a projection scale factor) It is scanned. Moreover, the wafer marks 12A and 12B for alignment are formed in each shot field on a wafer 7.

[0023] Next, exposure actuation of this example is explained. In this example, not only the lighting field of the shape of a slit on a reticle 4 but the other pattern space is illuminated at the time of scan exposure. That is, the illumination light IL 1, IL2A, and IL2B are injected from the three light source sections 1, 3A, and 3B, respectively at the same time scan exposure is started. Drawing 1 (b) shows the lighting field of the illumination light IL 1 on a reticle 4, IL2A, and IL2B, and the illumination light IL 1 from the light source section 1 is irradiated in this drawing 1 (b) by the rectangular lighting field 18 to which the points L1, L2, N1, and N2 which touch the effective exposure field (visual field) of projection optics 6 and the appearance of the circular effective lighting field [****] 14 were connected. In this case, the core P2 of the circular effective lighting field 14 is in agreement with an optical axis AX. On the other hand, illumination-light IL2A from light source section 3A is irradiated by the lighting field 17 of the trapezoidal shape of a left outside from the boundary line which connected the points L1 and N1 of the direction of -X of the lighting field 18. Moreover, illumination-light IL2B from light source section 3B is irradiated by the lighting field 19 of the trapezoidal shape of a right outside from the boundary line which connected the points L2 and N2 of the direction of +X of the lighting field 18. namely, the lighting fields 17 and 19 -- rotation -- it can be called the complement lighting field for complementing the lighting field 18 of an unsymmetrical rectangle and forming the lighting field near the circular effective lighting field 14. Both illumination-light IL2A which penetrated the illumination light IL 1 which penetrated the lighting field 18, and the lighting fields 17 and 19, respectively, and IL2B penetrate projection optics 6, and are irradiated on a wafer 7.

[0024] Drawing 1 (c) shows the lighting field on a wafer 7, and the photosensitive illumination light IL 1 is irradiated to the exposure field 21 of a long rectangle in this drawing 1 (c) by the non-scanning direction (the direction of Y) inscribed in the periphery of the circular effective exposure field 20 which is in agreement with the effective exposure field (visual field) IR of projection optics 6 at the photoresist of a wafer 7. In this case, the core P1 of the circular effective exposure field 20 is in agreement with an optical axis AX. And nonphotosensitivity illumination-light IL2A and IL2B are irradiated by the photoresist of a wafer 7, respectively to the lighting fields 22 and 23 which complement the exposure field 21 of the rectangle and form the lighting field near the circular effective exposure field 20.

[0025] That is, since the field near the symmetry of revolution is illuminated on a reticle 4 at the time of scan exposure and the lens within projection optics 6 is also mostly illuminated by the symmetry of revolution, the absorption consistency of the energy of the illumination light in the ** material of a lens serves as distribution near the symmetry of revolution. therefore, rotation of the lens of projection optics 6 -- unsymmetrical heat deformation etc. is suppressed and aberration fluctuation of projection optics 6 is suppressed. In this case, in order to lessen that aberration fluctuation as much as possible, as for the sum total area of the lighting fields 17 and 19 on the reticle 4 by each illumination-light IL2A from the light source sections 3A and 3B, and IL2B, it is desirable that it is 1/2 or more [of area other than lighting field 18 by the illumination light IL 1 in the effective lighting field 14].

[0026] Moreover, although illumination-light IL2A which penetrated the lighting fields 17 and 19 on a reticle 4, and IL2B are irradiated by the lighting fields 22 and 23 on a wafer 7, respectively, since illumination-light IL2A and IL2B are nonphotosensitivity at the photoresist on a wafer 7, on a wafer 7, only the image of the pattern in the lighting field 18 on a reticle 4 is imprinted. Moreover, in this example, illumination-light IL2A from the light source sections 3A and 3B and IL2B are used also as a detection light of the alignment sensor for the alignment of a reticle 4 and a wafer 7. Therefore, the alignment sensors 13A and 13B of an image-processing method are installed by the TTR method above the both ends of the direction of X of a reticle 4, and a field including the location in which the reticle marks 11A and 11B on a reticle 4 were formed, respectively in illumination-light IL2A injected from the light source sections 3A and 3B and IL2B is irradiated. And the relative location gap with the wafer marks 12A and 12B and the reticle marks 11A and 11B is detected using the alignment sensors 13A and

13B. In this case, it is not necessary to establish the light source for alignment sensors, and is efficient. In addition, the alignment sensor which detects separately the reticle marks 11A and 11B and the wafer marks 12A and 12B, respectively is sufficient as the alignment sensors 13A and 13B.

[0027] Next, the modification of the 1st example of the gestalt of operation of this invention is explained with reference to drawing 7 . This modification is constituted so that incidence of the illumination light from the light source sections 3A and 3B of drawing 1 may be carried out to the direct projection optics 6 from the lower part side of a reticle 4. Other configurations are the same as that of the 1st example, give the same sign to a corresponding part with drawing 1 in drawing 7 , and omit the explanation.

[0028] Drawing 7 (a) shows the outline configuration of the projection aligner of this modification, and the light source sections 3A and 3B which inject illumination-light IL2A of wavelength lambda 2 and IL2B like drawing 1 to right and left of the lower part of a reticle 4 are installed in this drawing 7 (a). Condensing lens 9A is penetrated, it is caudad reflected by mirror 33A installed to the direction of incidence of illumination-light IL2A, and incidence of the illumination-light IL2A from light source section 3A is carried out to projection optics 6. Condensing lens 9B is penetrated similarly, it is caudad reflected by mirror 33B installed to the direction of incidence of illumination-light IL2B, and incidence also of the illumination-light IL2B from another light source section 3B is carried out to projection optics 6. The following is the same as that of the 1st example.

[0029] Drawing 7 (b) shows the lighting field on a reticle 4, and the illumination light IL 1 from the light source section 1 is irradiated by the lighting field 18 of the rectangle inscribed in the appearance of the circular effective lighting field 14 in this drawing 7 (b). On the other hand, although each illumination-light IL2A from the light source sections 3A and 3B and IL2B are not irradiated on a reticle 4, the imagination lighting field on the reticle 4 which turned up the optical path by Mirrors 33A and 33B turns into the exposure fields 17A and 17B of the trapezoidal shape shown by the dotted line, respectively. Therefore, like the 1st example, distribution of the exposure energy of the lens of projection optics 6 serves as the symmetry of revolution mostly, and can reduce aberration fluctuation of projection optics 6.

[0030] This modification is an effective approach when Mirrors 16A and 16B cannot be arranged from the constraint on a tooth-space side or arrangement to the incidence side of a reticle 4 like the 1st example. However, in the case of this modification, it is sometimes difficult to distinguish clearly the boundary of the lighting field 18 of the illumination light IL 1 on a reticle 4, and the imagination lighting fields 17A and 19A by illumination-light IL2A from the light source sections 3A and 3B, and IL2B for KERARE of the illumination light IL 1 by Mirrors 33A and 33B.

[0031] Next, the 2nd example of the gestalt of operation by this invention is explained with reference to drawing 2 . This example installs the two light source sections, and supplies the illumination light which has energy distribution almost symmetrical with rotation in projection optics using the field diaphragm which has synthetic optical system and wavelength selection nature. The fundamental configuration is the same as that of the 1st example, gives the same sign to a corresponding part with drawing 1 in drawing 2 , and omits the detail explanation. In addition, the wafer stage etc. is omitted in drawing 2 .

[0032] Drawing 2 shows the outline configuration of the projection aligner of this example, the polarization beam splitter 42 which the illumination light IL 1 of the photosensitive wavelength lambda 1 became the parallel flux of light by the relay lens 41, and was installed to the optical path of the illumination light IL 1 in this drawing 2 by the photoresist on the wafer 7 injected from the light source section 1 is penetrated, and incidence is carried out to a condensing lens 46. In addition, the linearly polarized light of the illumination light IL 1 of this example and the IL2A shall be carried out to P polarization, respectively, and they shall carry out incidence to a polarization beam splitter 42. Illumination-light IL2A of the nonphotosensitivity wavelength lambda 2 also becomes the parallel flux of light by the relay lens 47, and carries out incidence to the photoresist on the wafer 7 injected from another light source section 3A from the direction which intersects perpendicularly with the illumination light IL 1 at a polarization beam splitter 42. A polarization beam splitter 42 is penetrated, it is reflected by the mirror 44 through the quarter-wave length plate 43, and incidence of the illumination-light IL2A is again carried out to a polarization beam splitter 42 as S polarization through the quarter-wave length

plate 43. It is reflected by the polarization beam splitter 42, and illumination-light IL2A used as S polarization is compounded with the illumination light IL 1 explained previously, carries out incidence to a condensing lens 46 as illumination light IL 3, and is irradiated on a reticle 4 through a condensing lens 46. Moreover, the quarter-wave length plate 45 is installed between a polarization beam splitter 42 and a condensing lens 46, and the illumination light IL 3 is mostly irradiated by the reticle 4 in the state of the circular polarization of light. A good imprint is performed by this even if the direction of the pattern of a reticle 4 changes.

[0033] The field diaphragm 48 which approaches and has wavelength selection nature is installed in the top face of a reticle 4, and each lighting field on the illumination light IL 1 which constitutes the illumination light IL 3 by this field diaphragm 48, and the reticle 4 of illumination-light IL2A is determined. The field diaphragm 48 consists of two kinds of light filters which have wavelength selection nature. Drawing 2 (b) shows the top view of a field diaphragm 48, and the light filter 50 of a long rectangle is formed in the non-scanning direction which penetrates the flux of light of wavelength lambda 1 alternatively in the center of a field diaphragm 48 in this drawing 2 (b). In this example, since the field diaphragm 48 is close with the reticle 4, the configuration of this light filter 50 can consider as it is that it is the lighting field of the illumination light IL 1 on a reticle 4. Moreover, the light filters 49 and 51 of the shape of a semicircle which penetrates alternatively illumination-light IL2A of wavelength lambda 2 are formed in right and left of the light filter 50 on a field diaphragm 48. And a light filter 50 and light filters 49 and 51 form the circular field centering on an optical axis AX as a whole, and this circular field is a field settled in the effective lighting field on a reticle 4.

[0034] After the illumination light IL 1 which passed the field diaphragm 48 in which these light filters 49-51 were formed, and IL2A penetrate a reticle 4, although projection optics 6 is passed further and it irradiates on a wafer 7, since illumination-light IL2A is nonphotosensitivity at the photoresist on a wafer 7, on a wafer 7, only the image of the pattern on the reticle 4 specified in the configuration of a light filter 50 is imprinted.

[0035] Moreover, by making projection optics 6 carry out incidence of the illumination light IL 1 injected from the light source section 1, and the illumination-light IL2A injected from light source section 3A to coincidence, the absorbed energy of the ** material within projection optics 6 becomes the density distribution near the symmetry of revolution to an optical axis AX, and its aberration fluctuation decreases. Moreover, like the conventional example, when heat deformation of the ** material of projection optics 6 is rotation asymmetry remarkably, the astigmatism (henceforth "main ASU") that the best image surface of the pattern of the meridional direction and the best image surface of the pattern of a direction perpendicular to it separate in the direction of an optical axis may arise at the core of the exposure field of projection optics. however, rotation of such [in this example] main ASU etc. -- generating of unsymmetrical aberration fluctuation is also suppressed. Moreover, the approach of this example is effective especially when using a radii-like exposure field as follows.

[0036] Drawing 2 (c) shows the condition of the field diaphragm used instead of a field diaphragm 48, when using a radii-like exposure field as an exposure field, and it sets it to this drawing 2 (c). In the center of field-diaphragm 48A, light filter 50A of the shape of radii which penetrates alternatively the illumination light IL 1 from the light source section 1 is arranged. Semicircle-like light filter 49A and falcation light filter 51A which penetrate alternatively illumination-light IL2A of wavelength lambda 2 are prepared in right and left of light filter 50A on field-diaphragm 48A. The configuration of these light filters 49A, 51A, and 50A is set up so that the circular field centering on an optical axis AX may be formed as a whole. In this example, the pattern inside radii-like light filter 50A is projected on a wafer 7 through projection optics 6 on a reticle 4. And the exposure energy of the symmetry of revolution is mostly supplied to projection optics 6 centering on an optical axis AX, and aberration fluctuation decreases.

[0037] Thus, in order to give exposure energy symmetrical with rotation to the ** material within projection optics 6 in the 1st example in the case of a radii-like lighting field, it is necessary to set the field diaphragm in the light source sections 1 and 3A and 3B as a very complicated configuration, and a manufacturing cost increases. However, according to this example, moreover according to it, the

configuration of the light filters 49A and 51A of illumination-light IL2A can also be set up easily that what is necessary is just to set up the configuration of light filter 50A according to the lighting field of the shape of radii on the reticle 4.
[0038] in addition, what is small in whether the permeability to illumination-light IL2A from light source section 3A is made as a light filter 50 of drawing 2 (b) -- the rotation within projection optics 6 -- the effectiveness of reducing the aberration fluctuation by unsymmetrical exposure energy distribution is greatly desirable. Moreover, in order to lessen aberration fluctuation of projection optics 6 as much as possible, as for the area of light filters 49 and 51, it is desirable that it is [of the area of parts other than light filter 50] 1/2 or more at least in in the circle circumscribed to a light filter 50.
[0039] Moreover, in the example of drawing 2 (a), although the field diaphragm 48 is set up near the pattern side of a reticle 4, it may arrange a field diaphragm 48 to the pattern side of a reticle 4, and a field [****]. In addition, in drawing 2 (a), instead of a polarization beam splitter 42, as a two-dot chain line shows as synthetic optical system, a dichroic mirror DM may be used. It has the wavelength selection nature which this dichroic mirror DM penetrates the illumination light IL 1, and reflects illumination-light IL2A, and both the illumination light IL 1 and IL2A are compounded by this without futility. Moreover, in this case, the quarter-wave length plate 45 is unnecessary.
[0040] Next, the 3rd example of the gestalt of operation of the projection aligner of this invention is explained with reference to drawing 8 . Only the one light source is used for this example, it prepares a gobo between projection optics and a wafer, gives the same sign to a corresponding part with drawing 1 or drawing 2 in drawing 8 , and omits the detail explanation. Drawing 8 (a) shows the outline configuration of the projection aligner of this example, and the photosensitive illumination light IL 1 is irradiated on a reticle 4 with a condensing lens 41 in this drawing 8 (a) to the photoresist injected from light source section 1A. In this case, it is not orthopedically operated by the rectangle like the lighting field 18 of drawing 1 , but the lighting field configuration on the reticle 4 of the illumination light IL 1 serves as the effective exposure field of projection optics 6, and a circular effective lighting field [****]. The illumination light IL 1 which passed through the circular effective lighting field on a reticle 4 penetrates projection optics 6, and it carries out incidence to the gobo 71 arranged by approaching a wafer 7.
[0041] Drawing 8 (b) shows the top view of a gobo 71, and the core's of a gobo 71 corresponds with an optical axis AX in this drawing 8 (b). The transparency field 73 of a long rectangle is formed in the direction of Y centering on an optical axis AX, and the protection-from-light band 72 is formed in the center section of the gobo 71 so that the transparency field 73 may be surrounded. Only the illumination light which penetrated the transparency field 73 among the illumination light IL 1 which carried out incidence to the gobo 71 is irradiated on a wafer 7. Thereby, on a wafer 7, the image of the pattern of the field of a long rectangle is imprinted in the direction of Y on the reticle 4 corresponding to the transparency field 73 of a gobo 71.
[0042] only forming a gobo 71 between projection optics 6 and a wafer 7 according to this example -- the desired rotation on a reticle 4 -- only the image of the pattern of an unsymmetrical field can be imprinted. Therefore, the configuration of the illumination-light study system for operating the lighting field of the illumination light IL 1 orthopedically becomes easy. Moreover, since only one light source section 1A is used, as compared with the example of drawing 1 , drawing 2 , and drawing 7 , a facility of the light source section, a condensing lens, etc. can be saved. Moreover, since what is necessary is just to form a gobo 71, a configuration is very easy and can also do the activity of adjustment etc. easily. Especially, in this example, in order to illuminate a reticle 4 and a field symmetrical with rotation of projection optics 6 by the illumination light IL 1 from one light source section 1A, the absorption density distribution of the light energy of the ** material of projection optics 6 serves as the symmetry of revolution around an optical axis AX further, and generating of the aberration of the projection optics 6 accompanying heat deformation of ** material is suppressed further.
[0043] In addition, the exchange style for replacing a gobo 71 may be prepared, and you may constitute so that two or more gobos which formed the configuration of a transparency field according to the exposure field may be exchanged through the exchange style. Moreover, the visual field adjustment

device which can be changed into arbitrary configurations may be established for the transparency field 73 instead of a gobo 71. In addition, in the example of drawing 8 , the distance d1 of finite exists between a wafer 7 and a gobo 71 for convenience' sake [structural]. [when the lighting unevenness on a wafer 7 poses a problem by KERARE by the gobo 71] If the maximum numerical aperture (NA) of the exposure light on a wafer 7 is set to sin theta as drawing 9 (a) shows Near a reticle 4 or rather than a reticle 4, in the conjugation location of the reticle 4 by the side of the light source It is good to arrange the member 80 which formed the protection-from-light bands 84 and 85 of width-of-face dR =2 beta-d 1 and tan theta (beta is the projection scale factor of 1/4, and a 1 / 5 grades) in the outside of the exposure field of the wafer 7 as shown by drawing 9 (b), and the field [****] 81. In this case, the illumination light IL 1 of drawing 8 (a) passes through the fields 81, 82, and 83 except the protection-from-light bands 84 and 85.
[0044] This sets to drawing 9 (a) and it is width of face dR. In the field from location 7A to 7B [****], exposure is not carried out at all on the protection-from-light band 85 and a wafer 7. If the boundary of the transparency field 73 of a gobo 71 and the protection-from-light band 72 is arranged above mid-position 7C with locations 7A and 7B and it is made the same also about the protection-from-light band 84 of another side, KERARE by the gobo 71 will not happen. width of face dR of the protection-from-light bands 84 and 85 when sufficiently smaller than the diameter of the circular member 80, the lens of the projection optics 6 of drawing 8 (a) is mostly illuminated to the symmetry of revolution -- having -- rotation -- unsymmetrical aberration fluctuation is fully amended.
[0045] Next, the effectiveness of reduction of aberration fluctuation of the projection optics in the gestalt of above-mentioned operation is explained based on the example of count. First, the rise of the temperature distribution by lighting energy is calculated. Therefore, in the example of drawing 1 , the lens of projection optics 6 is approximated to a cylindrical shape, and when heat does not flow out of the side face of a lens through air but the edge of a lens touches a metal, it is assumed that it is that into which heat flows only out of the edge of the lens. a radial distance of the lens -- about the surrounding include angle of r and an optical axis AX, in the temperature distribution after phi and a rise, if the absorbed duty per unit volume of T (r, phi) and a lens is set to omega (r, phi) and the circumradius of lambda and a lens is set to a for thermal conductivity, the heat conduction equation in the cylindrical coordinate system (r, phi) in a thermal equilibrium state will become like a degree type.
[0046]
[Equation 1]

$$\partial^2 T/\partial r^2+(1/r)\cdot\partial T/\partial r+(1/r^2)\cdot\partial^2 T/\partial\phi^2+\omega(r,\phi)/\lambda=0$$

[0047] Then, if the heat conduction equation of (several 1) is solved, it will become like a degree type.
[0048]
[Equation 2]

$$T(r,\phi)=\sum_{i=1}^{\infty}\sum_{n=0}^{\infty}C_{in}\cdot J_0(p_{in}\cdot r)\cos(n\phi)+\sum_{i=1}^{\infty}\sum_{n=0}^{\infty}S_{in}\cdot J_0(p_{in}\cdot r)\sin(n\phi)$$

[0049] Here, Jn (pin-r) is the n-th 1st sort bessel (Bessel) function (n= 0, 1 and 2, --), and pin (i= 1, 2, --) is a sequence of numbers with which Jn(pin-a) =0 is filled. Moreover, a multiplier Cin is expressed by the degree type.
[0050]
[Equation 3]

$$C_{in}=\int_0^a\int_0^{2\pi}(\omega(r,\phi)/\lambda)\cdot J_n(p_{in}\cdot r)\cdot\cos(n\phi)\cdot r\,dr\,d\phi\,/\{(\pi/2)\cdot p_{in}^2\cdot a^2[J_{n+1}(p_{in}\cdot a)]^2\}$$

[0051] However, as for a multiplier Cin, it asks by the degree type only at the time of n= 0.
[0052]
[Equation 4]

$$C_{in}=\int_0^a \int_0^{2\pi} (\omega(r,\phi)/\lambda)\cdot J_0(p_{i0}\cdot r)\cdot r\,d r\,d\phi$$
$$/\{\pi\cdot p_{i0}^2\cdot a^2[J_1(p_{i0}\cdot a)]^2\}$$

[0053] Moreover, a multiplier Sin is expressed by the degree type.
[0054]
[Equation 5]

$$S_{in}=\int_0^a \int_0^{2\pi} (\omega(r,\phi)/\lambda)\cdot J_0(p_{in}\cdot r)\cdot \sin(n\phi)\cdot r\,d r\,d\phi$$
$$/\{(\pi/2)\cdot p_{in}^2\cdot a^2[J_{n+1}(p_{in}\cdot a)]^2\}$$

[0055] Next, in order to investigate of which degree aberration fluctuation appears mostly by the rise of temperature distribution, the fourier BEKI expansion into series of the temperature distribution T after a rise (r, phi) is carried out with the least square method as follows. Here, the unit of the temperature distribution T after a rise (r, phi) is **, and the unit of distance r is mm.
[0056]
[Equation 6]

$$T(r,\phi)=\sum_{i=0}^{\infty}\sum_{n=0}^{\infty} B_{in}\cdot r^{i+n}\cdot \cos(n\phi)$$

[0057] However, they are i= 0, 2, 4 and 6, and --. Here, the series B00 in i= 0 and n= 0 becomes an optical axis AX, i.e., the rise temperature of r= 0. Hereafter, based on an actual numeric value, two examples of count, the 1st and the 2nd, explain the effectiveness in the 1st example. In the 1st example of count, a rectangular lighting field is used as a lighting field of the exposure light on a reticle, and a radii-like lighting field is used in the 2nd example of count. In this case, suppose that it is a lens 61 the quartz of the cylindrical shape whose circumradius a is 40mm with a lens 61 on behalf of the lens of projection optics 6 (refer to drawing 3 - drawing 6). In the case of a quartz, thermal conductivity is 0.0138W/(cmand**). Moreover, the rate of heat absorption of the lens 61 to the illumination light IL 1 of wavelength lambda 1 which exposes the photoresist of a wafer 7 is carried out in 2%/cm.
[0058] In the 1st example of count, it calculates first about the case where the illumination light IL 1 is irradiated by only the lighting field 18 of the 70mmx16.8mm rectangle on the reticle 4 of drawing 1 , for a comparison. In this case, it calculates based on the solution of the heat conduction equation at the time of substituting a rectangular absorbed energy consistency for the above (several 3), (several 4), and the absorbed duty omega (r, phi) that reaches (several 5), and substituting that result for (several 2).
[0059] Drawing 3 (a) shows the exposure condition on the lens 61 when the illumination light IL 1 is irradiated by only the rectangular lighting field, and sets it to this drawing 3 (a). drawing 1 -- (-- b --) -- lighting -- a field -- 18 -- a point -- L -- one -- L -- two -- N -- one -- N -- two -- corresponding -- a point -- L -- one -- ' -- L -- two -- ' -- N -- one -- ' -- N -- two -- ' -- surrounding -- having had -- a rectangle -- lighting -- a field -- 62 -- a scanning direction -- width of face -- DX -- and -- un--- a scanning direction -- width of face -- DY -- respectively -- 16.8mm and 70mm -- carrying out . And the lighting field 62 shall be uniformly irradiated by the illumination light IL 1, and sets the total exposure per unit time amount to 1W.
[0060] Drawing 3 (b) expresses the above count result to drawing, and an axis of abscissa and an axis of ordinate express the distance x from an optical axis AX to a scanning direction, and the distance y to a non-scanning direction, respectively. In this drawing 3 (b), constant-temperature-line 63A for 0.02

degrees C of every temperature gradients shows the temperature distribution on a lens 61. In addition, temperature serves as a low value from the inside towards the outside. In addition, also in drawing 4 (b) explained below - drawing 6 (b), an axis of abscissa and an axis of ordinate express the distance x from an optical axis AX to a scanning direction, and the distance y to a non-scanning direction, respectively, and the constant-temperature lines 63B-63D show the constant-temperature line for 0.02 degrees C of every temperature gradients which fall toward an outside from the inside.
[0061] although only the case that the illumination light ILI is irradiated by the lighting field 62 of the rectangle on a lens 61 serves as temperature distribution near the symmetry of revolution in the location distant from the optical axis AX on a lens 61 as shown in constant-temperature-line 63A of the shape of an ellipse long to the non-scanning direction centering on the optical axis AX of this drawing 3 (b) -- the near optical axis AX (x= 0, y= 0) -- rotation -- they are unsymmetrical temperature distribution.
[0062] Table 1 shows the series Bin which carried out the fourier BEKI expansion into series by the above (several 6), n (0, 1, 2, --) is taken in the horizontal column, i (= 0, 2, 4, --) is taken to a column, and the value of the series Bin corresponding to each value of n and i is shown. Table 1 is explained later. In addition, the value of Series Bin is shown like [Table 2 - 4 mentioned later] Table 1.
[0063]
[Table 1]

	n=0	n=1	n=2	n=3	n=4
i=0	2.2045×10^{-1}	0.0000	-2.4550×10^{-4}	0.0000	1.4452×10^{-7}
i=2	-3.4345×10^{-4}	0.0000	6.3423×10^{-7}	0.0000	-3.3489×10^{-10}
i=4	3.9964×10^{-7}	0.0000	-8.4516×10^{-10}	0.0000	3.1901×10^{-13}
i=6	-3.6972×10^{-10}	0.0000	6.5133×10^{-13}	0.0000	-1.4221×10^{-16}
i=8	1.8007×10^{-13}	0.0000	-2.6076×10^{-16}	0.0000	2.1215×10^{-20}
i=10	-3.4325×10^{-17}	0.0000	4.1520×10^{-20}	0.0000	1.7302×10^{-24}

[0064] Next, in addition to the illumination light IL 1 from the light source section 1, based on the 1st example of drawing 1 , the count result at the time of irradiating the lens 61 of projection optics 6 by illumination-light IL2A from the light source sections 3A and 3B and IL2B is shown. In addition, although the exposure field of illumination-light IL2A from the light source sections 3A and 3B and IL2B differs from the 1st example for a while, in respect of effectiveness, you may think that it is the same.
[0065] the right and left which drawing 4 (a) shows the exposure condition on a lens 61, and touch the lighting field 62 in this drawing 4 (a) within the circle in which the lighting field 62 is inscribed -- suppose that illumination-light IL2A and IL2B are mostly irradiated uniformly by the lighting fields 64A and 64B of a hemicycle, respectively. In this case, let the absorbed energy consistency of the lens 61 to illumination-light IL2A of wavelength lambda 2 which does not expose the photoresist of a wafer 7, and IL2B be the absorbed energy consistency and equal to the illumination light IL 1 in the lighting field 62.
[0066] Drawing 4 (b) expresses the above count result to drawing, and in this drawing 4 (b), as shown in concentric circular constant-temperature-line 63B centering on the optical axis AX on a lens 61, it serves as temperature distribution almost near the symmetry of revolution on the lens 61. Moreover, based on the above count result, the result of having calculated the series Bin which carried out the fourier BEKI expansion into series by the above (several 6) is shown in Table 2.
[0067]
[Table 2]

	n=0	n=1	n=2	n=3	n=4
i=0	4.8298×10^{-1}	0.0000	1.7294×10^{-7}	0.0000	1.4426×10^{-9}
i=2	-3.0498×10^{-4}	0.0000	5.4971×10^{-9}	0.0000	-1.4191×10^{-11}
i=4	-2.5533×10^{-8}	0.0000	-1.8367×10^{-11}	0.0000	3.8396×10^{-14}
i=6	6.3606×10^{-11}	0.0000	2.5913×10^{-14}	0.0000	-4.7191×10^{-17}
i=8	-6.1809×10^{-14}	0.0000	-1.5972×10^{-17}	0.0000	2.6709×10^{-20}
i=10	2.0495×10^{-17}	0.0000	3.4875×10^{-21}	0.0000	-5.6051×10^{-24}

[0068] If the temperature distribution after each rise of drawing 3 (b) and drawing 4 (b) are compared, the direction of the temperature distribution of drawing 4 (b) is quite close to the symmetry of revolution. Furthermore, although the series B00 in i= 0 and n= 0, i.e., the temperature in an optical axis AX (r= 0), has a large direction in the case of Table 2 when Table 1 is compared with Table 2, in most, Table 2 of the absolute value of the other series is smaller. rotation according [that it is shown that that the value of series other than i=0 is small among the values of Series Bin at n= 0 has the small spherical-aberration fluctuation by the exposure of the illumination light, and the value of n= 2 other than n=0 or the series Bin of n= 4 is small] to the exposure of the illumination light -- it expresses that unsymmetrical aberration fluctuation is small. namely, rotation of main ASU according to the exposure of the illumination light by the 1st example of drawing 1 etc. -- it turns out that unsymmetrical aberration fluctuation is reduced.

[0069] Next, the 2nd example of count is explained. This 2nd example of count shows concretely the effectiveness in the case of using a radii-like lighting field numerically in the 1st example shown in drawing 1 . First, it calculates about the case where the illumination light IL 1 of drawing 1 is irradiated by only the lighting field of the shape of radii on a reticle, for a comparison. Drawing 5 (a) shows the exposure condition of the illumination light IL 1 on the lens 61 of projection optics 6, and the lens 61 is illuminated by the lighting field 65 of the shape of radii which has the same area as the lighting field 62 (refer to drawing 3 (a)) of the rectangle of the 1st example of count, and has the same circumscribed circle in this drawing 5 (a). In order that this lighting field 65 may avoid the flare of the core of projection optics 6, it is formed so that the field in the circle whose distance from an optical axis AX is 8.4mm may not be included, and the core 66 of the lighting field 65 is set as the location of the predetermined distance d from the optical axis AX. In addition, the amount of exposure energy in the lens 61 of the illumination light IL 1 is 1W. Consequently, the distance DS with which the distance DR which connects linearly the points L3 and L4 (or points N3 and N4) of the corner of the two directions of Y of the radii-like lighting field 65 connects linearly the points L4 and N4 (or points L3 and N3) of the corner of the two directions of X, 16.8mm and the lighting field 65, is 70mm. And in order to avoid the field in a 8.4mm circle from an optical axis AX, it is set up so that the distance S of the direction of X between the tangents of the radii on the left-hand side of the lighting field 65 may be set to 25.2mm from the straight line which connects the points N3 and L3 of drawing 5 (a).

[0070] Drawing 5 (b) shows the result of having calculated the temperature distribution after the rise on the lens 61 when only the lighting field 65 of the shape of radii on a lens 61 is illuminated by the illumination light IL 1, and as this drawing 5 (b) is shown in constant-temperature-line 63C in every 0.02 degrees C, temperature distribution turn into temperature distribution of the shape of an ellipse long to the non-scanning direction which leaned toward right-hand side to the optical axis AX. The series Bin which carried out the fourier BEKI expansion into series in this case is shown in Table 3.

[0071]

[Table 3]

	n=0	n=1	n=2	n=3	n=4
i=0	1.6014×10^{-1}	6.3301×10^{-3}	3.3891×10^{-5}	-3.3261×10^{-6}	-6.5666×10^{-6}
i=2	-2.4216×10^{-6}	-1.0578×10^{-5}	-3.7951×10^{-7}	5.5797×10^{-9}	3.0172×10^{-10}
i=4	-2.8996×10^{-7}	4.9472×10^{-9}	7.4108×10^{-10}	-2.8098×10^{-12}	-4.5946×10^{-13}
i=6	3.6629×10^{-10}	2.0428×10^{-12}	-6.3917×10^{-13}	3.1792×10^{-17}	3.3061×10^{-16}
i=8	-2.0179×10^{-18}	-2.6958×10^{-15}	2.7273×10^{-16}	2.8736×10^{-19}	-1.1903×10^{-19}
i=10	4.2277×10^{-17}	6.8976×10^{-19}	-4.7047×10^{-20}	-4.0149×10^{-23}	1.7651×10^{-23}

[0072] Next, in addition to the illumination light IL 1 from the light source section 1, in drawing 1 (a), the example of count at the time of irradiating a lens 61 by illumination-light IL2A from the light source sections 3A and 3B and IL2B is shown. Drawing 6 (a) shows the exposure condition on a lens 61, and presupposes that illumination-light IL2A and IL2B are uniformly irradiated by the lighting fields 67A and 67B of the hemicycle of the right and left which touch the lighting field 65, respectively in this drawing 6 (a). In this case, as mentioned above, so that the lighting field of illumination-light IL2A from the light source sections 3A and 3B and IL2B may be aligned with a radii-like lighting field It is not easy to manufacture the light source sections 3A and 3B etc., and it sets for this example of count. As shown in drawing 6 (a), illumination-light IL2A and IL2B shall be irradiated by lighting field 67B of the shape of a semicircle which makes one side the tangent of the radii on the right-hand side of lighting field 67A which makes one side the straight line which connects the top-most vertices of the direction of -X of the radii-like lighting field 65, and the radii-like lighting field 65, respectively. And let the absorbed energy consistency of the lens 61 in the lighting fields 67A and 67B by illumination-light IL2A of the wavelength lambda 2 which is not exposed to a photoresist, and IL2B be radii-like the absorbed energy consistency and equal in the lighting field 65.
[0073] Drawing 6 (b) expresses the count result in the above conditions to drawing, and the temperature distribution shown by constant-temperature-line 63D are close to the symmetry of revolution in this drawing 6 (b) compared with the temperature distribution of drawing 5 (b). Moreover, based on the above count result, the result of having calculated the series Bin which carried out the fourier BEKI expansion into series by the above (several 6) is shown in Table 4.
[0074]
[Table 4]

	n=0	n=1	n=2	n=3	n=4
i=0	3.2613×10^{-1}	1.9780×10^{-3}	1.8782×10^{-4}	-4.4163×10^{-6}	-1.4622×10^{-7}
i=2	-9.3395×10^{-6}	-9.7035×10^{-6}	-6.8352×10^{-7}	1.8846×10^{-8}	6.0409×10^{-10}
i=4	-4.7485×10^{-7}	1.9335×10^{-9}	1.1776×10^{-9}	-3.2278×10^{-11}	-9.7362×10^{-13}
i=6	5.3783×10^{-10}	-1.9862×10^{-11}	-1.0660×10^{-12}	2.8311×10^{-14}	7.7335×10^{-16}
i=8	-3.1285×10^{-13}	1.0210×10^{-14}	4.8154×10^{-16}	-1.2630×10^{-17}	-3.0439×10^{-19}
i=10	7.1741×10^{-17}	-2.0517×10^{-18}	-8.5698×10^{-20}	2.2606×10^{-21}	4.7624×10^{-23}

[0075] When Table 3 and 4 is compared, the absolute value of series Bin other than [the great portion of] series B00 which show the temperature rise in an optical axis AX cannot say that the value of Table 4 is smaller than the value of Table 3, but the series of a big value also has considerably a direction in the case of drawing 6 (Table 4). namely, extent of an improvement of rotation asymmetry of the

temperature distribution on a lens 61 in the approach by the 1st example which is shown in drawing 1 in the case of a radii-like exposure field -- small -- rotation -- the reduction effectiveness of unsymmetrical aberration fluctuation is small. Therefore, if the lighting field by the illumination light of the wavelength which does not expose the photoresist on a wafer with a light filter, and is absorbed by the lens of projection optics 6 like the gestalt of operation shown in drawing 2 is set up so that it may touch that there is no clearance in a radii-like lighting field, in the case of a radii-like exposure field, the symmetry-of-revolution nature of the exposure energy distribution on the lens of projection optics 6 improves, and it can reduce aberration fluctuation of projection optics.

[0076] in addition, this invention -- the projection aligner of one-shot exposure molds, such as not only the projection aligner of a scan exposure mold but a stepper method, -- it is -- the rotation on a reticle -- when imprinting the pattern of an unsymmetrical field on a wafer, it can apply similarly. Thus, this invention is not limited to the gestalt of above-mentioned operation, but can take configurations various in the range which does not deviate from the summary of this invention.

[0077]

[Effect of the Invention] the rotation on the mask illuminated by the 1st illumination light since the 2nd illumination light is nonphotosensitivity to a photosensitive substrate according to the 1st projection aligner of this invention, although the 1st and 2nd illumination light is irradiated [both] on a photosensitive substrate -- the image of the pattern of an unsymmetrical exposure lighting field -- the rotation on a photosensitive substrate -- an unsymmetrical exposure lighting field imprints. moreover, rotation according to the 1st illumination light by the 2nd illumination light -- an unsymmetrical exposure lighting field is complemented, and in order to illuminate projection optics by the illumination light which passed through the exposure lighting field almost symmetrical with rotation, the symmetry-of-revolution nature of the exposure energy distribution to the lens of projection optics increases. therefore, rotation -- heat deformation of the lens by distribution of unsymmetrical heat energy, and rotation of a refractive index -- unsymmetrical distribution decreases and there is an advantage whose aberration fluctuation of projection optics decreases.

[0078] Moreover, according to the 2nd projection aligner of this invention, the 1st and 2nd illumination light once compounded by the synthetic system passes through the field determined by the field diaphragm, respectively, and is irradiated on a photosensitive substrate through projection optics. Since the 2nd illumination light is nonphotosensitivity to a photosensitive substrate, the image of the pattern on a mask is imprinted by the exposed lighting field on the photosensitive substrate only by the 1st illumination light. in this case, the 1st illumination light -- a field diaphragm -- rotation of a mask -- in order to pass only the 1st field as an unsymmetrical exposed lighting field, and the 1st transparency section [****], on a photosensitive substrate, only the image of the pattern of the 1st field on a mask is imprinted. On the other hand, the 1st illumination light which penetrates the 1st field on a mask, and the 2nd illumination light which penetrates the 2nd field on the mask which complements the 1st field and forms a circular field symmetrical with rotation substantially carry out incidence to projection optics. Since the exposure field of the 1st and 2nd whole illumination light turns into a circular field substantial almost symmetrical with rotation, like the 1st projection aligner of this invention, the symmetry-of-revolution nature of the exposure energy distribution to the lens of projection optics increases, and it has the advantage whose aberration fluctuation of projection optics decreases. moreover -- this invention -- the rotation on a mask -- there is also an advantage from which the optical system for operating orthopedically the optical system for operating orthopedically the 1st illumination light irradiated by the unsymmetrical exposed lighting field and the lighting field of the 2nd illumination light becomes unnecessary.

[0079] Moreover, the light from at least one side of the mask mark on the mask located in the field which the 2nd illumination light illuminates in the 1st and 2nd projection aligners of this invention, and the substrate mark on the photosensitive substrate located in the field which the 2nd illumination light illuminates is detected in photoelectricity. In having the mark location detection system which detects the location of one [at least] mark of both marks, there is an advantage which can use the 2nd illumination light effectively also as illumination light for the alignment for detecting the location of a

mask or a photosensitive substrate.

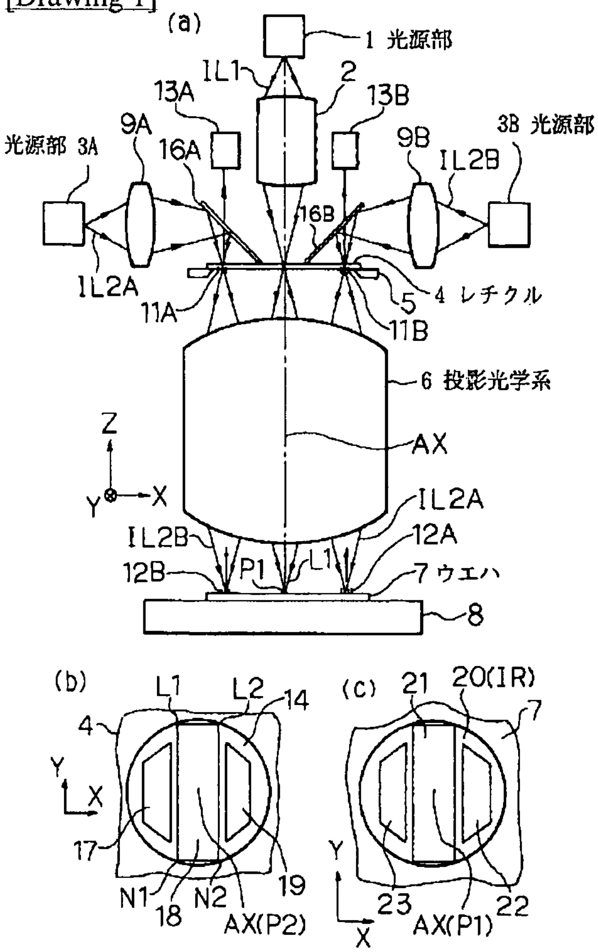
[0080] Moreover, when a predetermined circular exposure field symmetrical with rotation, or a predetermined circular field symmetrical with rotation and the field on a photosensitive substrate [****] is in agreement with the visual field by the side of the photosensitive substrate of projection optics, since the lens of projection optics is illuminated by the almost circular lighting field of an overall diameter by the symmetry of revolution, it has the advantage whose symmetry-of-revolution nature of distribution of the exposure energy to the lens of projection optics improves.

[0081] moreover -- according to the 3rd projection aligner of this invention -- a photosensitive substrate -- receiving -- the photosensitive illumination light -- an optical limit member -- the rotation on a mask -- it passes only through the field corresponding to an unsymmetrical field, and irradiates on a photosensitive substrate. therefore, the rotation on a mask -- only the image of the unsymmetrical pattern of a field is imprinted on a photosensitive substrate. Moreover, since the field almost symmetrical with rotation on a mask can be illuminated by the illumination light, the symmetry-of-revolution nature of the exposure energy distribution to the lens of projection optics increases like the 1st and 2nd projection aligners of this invention. Especially in this invention, in order to illuminate a mask only by one illumination light, the light energy of uniform wavelength is irradiated by the whole lens of projection optics. Therefore, it becomes uniform with the whole lens, heat deformation of a lens decreases further, and the absorbed amount of the heat energy in the lens of projection optics also has the advantage on which aberration fluctuation of projection optics is also suppressed further. Moreover, in order to use only one illumination light, there is also an advantage which can save a facility of the light source, an illumination-light study system, etc.

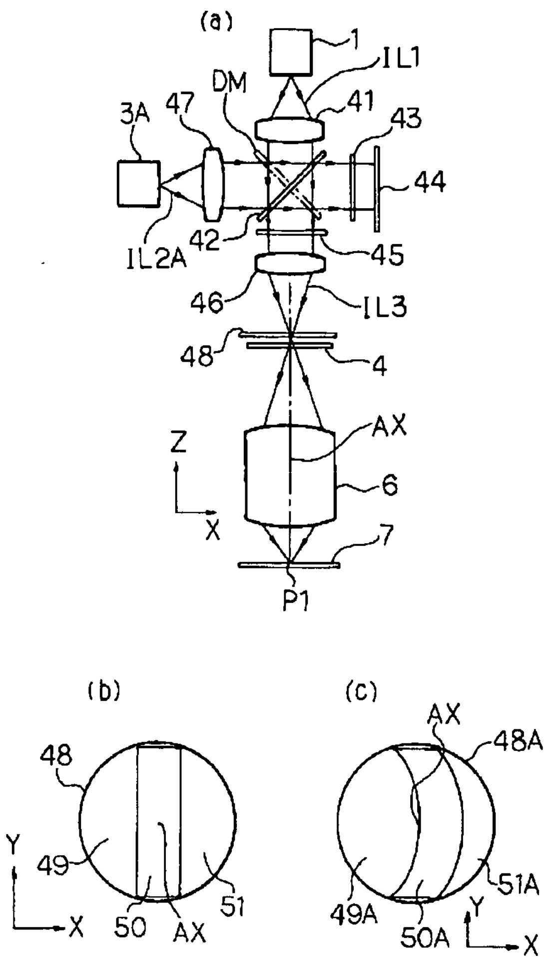
[Translation done.]

DRAWINGS

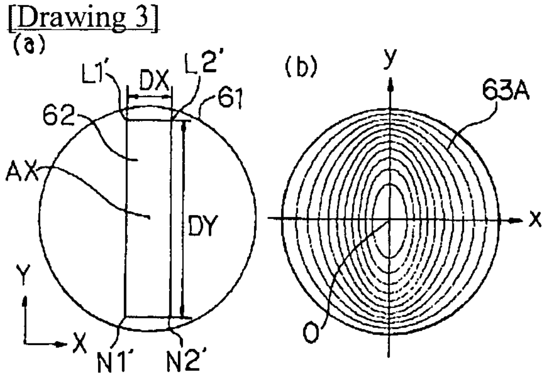
[Drawing 1]



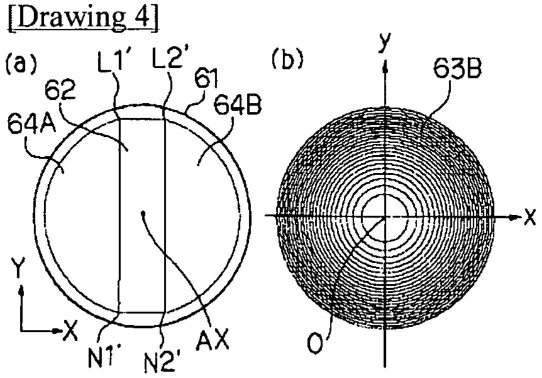
[Drawing 2]



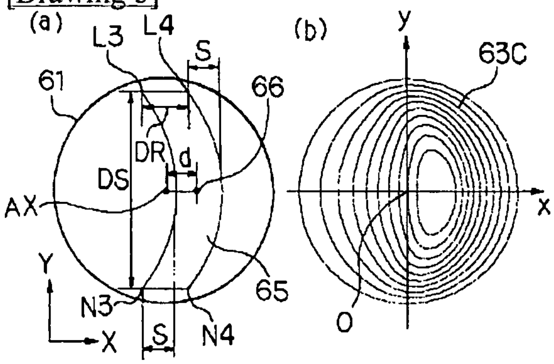
[Drawing 3]



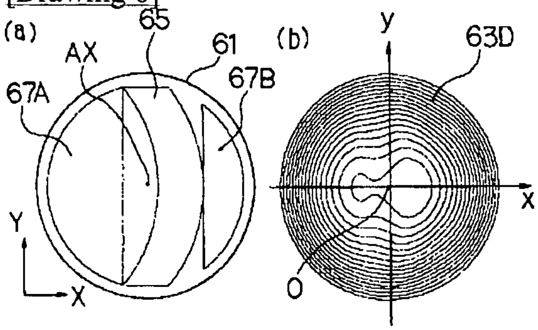
[Drawing 4]



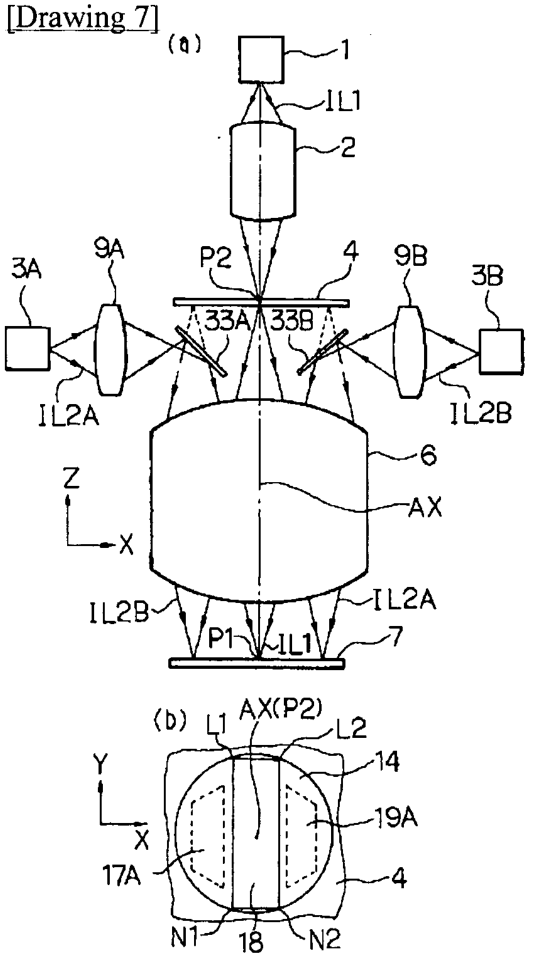
[Drawing 5]



[Drawing 6]

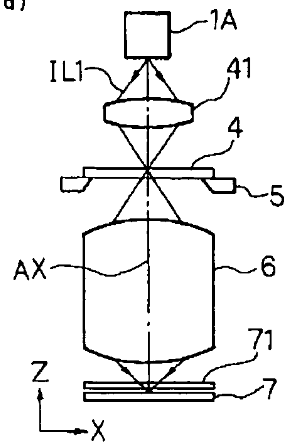


[Drawing 7]

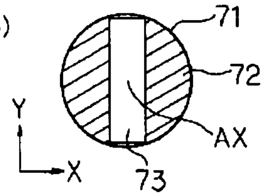


[Drawing 8]

(a)

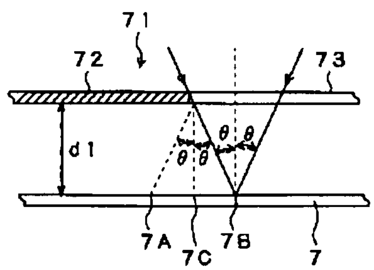


(b)

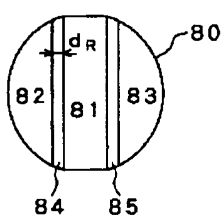


[Drawing 9]

(a)



(b)



[Translation done.]

CORRECTION OR AMENDMENT

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[Procedure amendment 1]
[Document to be Amended] Specification
[Item(s) to be Amended] The name of invention
[Method of Amendment] Modification
[The contents of amendment]
[Title of the Invention] The projection exposure approach and equipment
[Procedure amendment 2]
[Document to be Amended] Specification
[Item(s) to be Amended] Claim
[Method of Amendment] Modification
[The contents of amendment]
[Claim(s)]
[Claim 1]
Projection optics which projects the predetermined pattern for an imprint formed in the mask on a photosensitive substrate,
It sets in a predetermined circular exposure field symmetrical with rotation to the 1st point that the optical axis of said projection optics and the exposed field of said photosensitive substrate cross. said 1st point -- receiving -- rotation -- an unsymmetrical exposure lighting field -- forming -- rotation, in order

to imprint an unsymmetrical mask pattern image on said photosensitive substrate the 2nd point that supply the 1st illumination light with the wavelength which exposes said photosensitive substrate, and the optical axis of said projection optics and the pattern side of said mask cross -- receiving -- the inside of the pattern side of said mask -- rotation -- the 1st illumination system which forms an unsymmetrical exposure lighting field,
the 2nd illumination light which has nonphotosensitivity wavelength towards said photosensitive substrate through said projection optics -- supplying -- said 1st illumination light -- following -- the inside of said predetermined circular exposure field -- the whole illuminates mostly -- as -- said rotation in the exposed field of said photosensitive substrate -- the projection aligner characterized by to have the 2nd illumination system which forms the non-exposing lighting field which complements an unsymmetrical exposure lighting field in said predetermined circular exposure field.
[Claim 2]
Projection optics which projects the predetermined pattern for an imprint formed in the mask on a photosensitive substrate,
The 1st light source section which supplies the 1st illumination light with the wavelength which exposes said photosensitive substrate,
The 2nd light source section which supplies the 2nd illumination light which has nonphotosensitivity wavelength to said photosensitive substrate,
The synthetic system which compounds said 1st illumination light and said 2nd illumination light, and is led to said mask,
The field diaphragm arranged in the location which serves as conjugate substantially with the pattern side of said mask on the optical path between this synthetic system and said mask is prepared,
Said field diaphragm has the 1st transparency section which makes said 1st illumination light penetrate, and the 2nd transparency section which makes said 2nd illumination light penetrate,
the predetermined point that the optical axis of said projection optics and the pattern side of said mask cross, as for said 1st transparency section -- receiving -- the inside of a predetermined circular field symmetrical with rotation -- setting -- said predetermined point -- receiving -- rotation -- the 1st field as an unsymmetrical exposure lighting field, and conjugation -- it is
the inside of a predetermined circular field symmetrical with said rotation when said 2nd transparency field is accompanied by said 1st illumination light -- the whole is illuminated mostly -- as -- said rotation -- the projection aligner characterized by being the 2nd field as an exposed lighting field and conjugation which complement the 1st unsymmetrical field.
[Claim 3]
It is a projection aligner according to claim 1 or 2,
The projection aligner characterized by to have the mark location detection system which detects in photoelectricity the light from at least one side of the mask mark on said mask located in the field which said 2nd illumination light illuminates, and the substrate mark on said photosensitive substrate located in the field which said 2nd illumination light illuminates, and detects the location of one [at least] mark of both marks.
[Claim 4]
It is a projection aligner claims 1 and 2 or given in three,
A predetermined circular exposure field symmetrical with said rotation, or a predetermined circular field symmetrical with said rotation and the field on said photosensitive substrate [****] is a projection aligner characterized by being in agreement with the visual field by the side of said photosensitive substrate of said projection optics.
[Claim 5]
Projection optics which projects the predetermined pattern for an imprint formed in the mask on a photosensitive substrate,
The illumination-light study system which illuminates said mask by the illumination light with the wavelength which exposes said photosensitive substrate,
It is arranged between said projection optics and said photosensitive substrates, and an optical limit

member with the predetermined light transmission section is prepared,
the predetermined point that the optical axis of said projection optics and the exposed field of said photosensitive substrate cross, as for said illumination light which passed the light transmission section of this optical limit member -- receiving -- the inside of a predetermined circular exposure field symmetrical with rotation -- setting -- said predetermined point -- receiving -- rotation -- the projection aligner characterized by carrying out incidence to an unsymmetrical field.
[Claim 6]
In the projection aligner which carries out projection exposure of the image of the predetermined pattern for an imprint formed in the mask using projection optics on a photosensitive substrate,
the 1st illumination light with the wavelength which exposes said photosensitive substrate -- using -- the optical axis of projection optics -- being related -- rotation -- the illumination-light study system which forms an unsymmetrical lighting field on said mask -- having
said projection optics -- said rotation -- the image of said predetermined pattern for an imprint formed in said mask based on said 1st illumination light from an unsymmetrical lighting field -- the inside of the field on said photosensitive substrate -- projecting
rotation of said projection optics -- the projection aligner characterized by having further a rotation unsymmetrical aberration fluctuation reduction means to supply the 2nd illumination light which has nonphotosensitivity wavelength to said photosensitive substrate to said projection optics in order to reduce unsymmetrical aberration fluctuation.
[Claim 7]
In a projection aligner according to claim 6,
Said rotation unsymmetrical aberration fluctuation reduction means is a projection aligner characterized by supplying said 2nd illumination light to said projection optics through said mask.
[Claim 8]
In a projection aligner according to claim 6,
Said rotation unsymmetrical aberration fluctuation reduction means is a projection aligner characterized by supplying said 2nd illumination light to said projection optics from between said masks and said photosensitive substrates.
[Claim 9]
In the projection aligner of claim 6-8 given in any 1 term,
It exposes moving said mask and said photosensitive substrate to a scanning direction with the velocity ratio according to the projection scale factor of said projection optics,
For said scanning direction, said illumination-light study system is a projection aligner characterized by forming a long lighting field in a different non-scanning direction.
[Claim 10]
In the projection aligner of claim 6-9 given in any 1 term,
Said rotation unsymmetrical aberration fluctuation reduction means is a projection aligner characterized by amending the astigmatism of said projection optics in the core of said exposure field.
[Claim 11]
In the projection aligner of claim 6-10 given in any 1 term,
Said projection optics is equipped with a lens,
Said rotation unsymmetrical aberration reduction means is a projection aligner characterized by making mostly distribution of the exposure energy of said lens of said projection optics into the symmetry of revolution.
[Claim 12]
In the projection exposure approach which carries out projection exposure of the image of the predetermined pattern for an imprint formed in the mask using projection optics on a photosensitive substrate,
the 1st illumination light with the wavelength which exposes said photosensitive substrate -- using -- the optical axis of projection optics -- being related -- rotation -- the lighting process which forms an unsymmetrical lighting field on said mask, and;

said rotation -- the projection process which projects the image of said predetermined pattern for an imprint formed in said mask into the exposure field on said photosensitive substrate based on said 1st illumination light from an unsymmetrical lighting field, and;
the 2nd illumination light which has nonphotosensitivity wavelength to said photosensitive substrate -- said projection optics -- supplying -- rotation of said projection optics -- the rotation unsymmetrical aberration fluctuation reduction process and; which reduce unsymmetrical aberration fluctuation preparation ****** -- the projection exposure approach characterized by things.
[Claim 13]
In the projection exposure approach according to claim 12,
The projection exposure approach characterized by supplying said 2nd illumination light to said projection optics through said mask at said rotation unsymmetrical aberration fluctuation reduction process.
[Claim 14]
In the projection exposure approach according to claim 12,
The projection exposure approach characterized by supplying said 2nd illumination light to said projection optics from between said masks and said photosensitive substrates by said rotation unsymmetrical aberration fluctuation reduction approach.
[Claim 15]
In the projection exposure approach of claim 12-14 given in any 1 term,
It exposes moving said mask and said photosensitive substrate to a scanning direction with the velocity ratio according to the projection scale factor of said projection optics,
The projection exposure approach characterized by forming a long lighting field in a different non-scanning direction from said scanning direction at said lighting process.
[Claim 16]
In the projection exposure approach of claim 12-15 given in any 1 term,
The projection exposure approach characterized by amending the astigmatism of said projection optics in the core of said exposure field at said rotation unsymmetrical aberration fluctuation reduction process.

[Claim 17]
In the projection exposure approach of claim 12-16 given in any 1 term,
Said projection optics is equipped with a lens,
The projection exposure approach characterized by making mostly distribution of the exposure energy of said lens of said projection optics into the symmetry of revolution at said rotation unsymmetrical aberration reduction process.
[Procedure amendment 3]
[Document to be Amended] Specification
[Item(s) to be Amended] 0006
[Method of Amendment] Modification
[The contents of amendment]
[0006]
this invention -- this point -- taking an example -- the rotation on a reticle -- when imprinting the pattern of an unsymmetrical field on a wafer through projection optics, it aims at offering little projection exposure approach and equipment of aberration fluctuation of projection optics.
[Procedure amendment 4]
[Document to be Amended] Specification
[Item(s) to be Amended] 0015
[Method of Amendment] Modification
[The contents of amendment]
[0015]
the light limit member (71) after the photosensitive illumination light (IL1) passes through a mask (4) and a field symmetrical with rotation of projection optics (6) to a photosensitive substrate (6) according

to the 3rd projection aligner of this this invention -- the rotation on a mask (4) -- it passes only through the field corresponding to an unsymmetrical field, and irradiates on a photosensitive substrate (7). therefore, the rotation on a mask (4) -- only the image of the unsymmetrical pattern of a field is imprinted on a photosensitive substrate (7). Moreover, in order to illuminate a field symmetrical with the rotation on a mask (4) by the illumination light (IL1), like the 1st and 2nd projection aligners of this invention, the symmetry-of-revolution nature of the exposure energy distribution to the lens of projection optics (6) increases, and aberration fluctuation of projection optics (6) decreases. Especially in this invention, in order to illuminate a mask (4) only by one illumination light (IL1), the light energy of uniform wavelength is irradiated by the whole lens of projection optics (6). therefore, the absorbed amount of the heat energy in these lenses -- uniform -- becoming -- rotation of a lens -- unsymmetrical heat deformation decreases further and generating of the aberration of projection optics (6) is also suppressed further. Moreover, since only one illumination light (IL1) is used, a facility of the light source, an illumination-light study system, etc. can be saved.

Next, the 4th projection aligner by this invention is set to the projection aligner which carries out projection exposure of the image of the predetermined pattern for an imprint formed in the mask using projection optics on a photosensitive substrate. It has the illumination-light study system which forms an unsymmetrical lighting field on the mask. the 1st illumination light with the wavelength which exposes the photosensitive substrate -- using -- the optical axis of projection optics -- being related -- rotation -- the projection optics the rotation -- the image of the predetermined pattern for an imprint formed in the mask based on the 1st illumination light from an unsymmetrical lighting field -- the inside of the field on the photosensitive substrate -- projecting -- rotation of the projection optics, in order to reduce unsymmetrical aberration fluctuation It has further a rotation unsymmetrical aberration fluctuation reduction means to supply the 2nd illumination light which has nonphotosensitivity wavelength to the photosensitive substrate to the projection optics.

In this case, that rotation unsymmetrical aberration fluctuation reduction means supplies that 2nd illumination light to that projection optics through that mask as an example.

Moreover, the rotation unsymmetrical aberration fluctuation reduction means supplies the 2nd illumination light to the projection optics from between the mask and its photosensitive substrate as another example.

Moreover, it may expose moving the mask and its photosensitive substrate to a scanning direction with the velocity ratio according to the projection scale factor of the projection optics, and the illumination-light study system may form a long lighting field in a different non-scanning direction from the scanning direction.

Moreover, the rotation unsymmetrical aberration fluctuation reduction means may amend the astigmatism of the projection optics in the core of the exposure field.

Moreover, the projection optics may be equipped with a lens and the rotation unsymmetrical aberration reduction means may make mostly distribution of the exposure energy of the lens of the projection optics the symmetry of revolution.

Next, the projection exposure approach by this invention is set to the projection exposure approach which carries out projection exposure of the image of the predetermined pattern for an imprint formed in the mask using projection optics on a photosensitive substrate. It is based on the 1st illumination light from an unsymmetrical lighting field. the 1st illumination light with the wavelength which exposes the photosensitive substrate -- using -- the optical axis of projection optics -- being related -- rotation -- the lighting process which forms an unsymmetrical lighting field on the mask, and; -- the rotation -- The projection process which projects the image of the predetermined pattern for an imprint formed in the mask into the exposure field on the photosensitive substrate; As opposed to the photosensitive substrate the 2nd illumination light with nonphotosensitivity wavelength -- the projection optics -- supplying -- rotation of the projection optics -- it has the rotation unsymmetrical aberration fluctuation reduction process of reducing unsymmetrical aberration fluctuation.

In this case, at that rotation unsymmetrical aberration fluctuation reduction process, that 2nd illumination light is supplied to that projection optics through that mask as an example.

Moreover, by the rotation unsymmetrical aberration fluctuation reduction approach, the 2nd illumination light is supplied to the projection optics from between the mask and its photosensitive substrate as another example.
Moreover, it may expose moving the mask and its photosensitive substrate to a scanning direction with the velocity ratio according to the projection scale factor of the projection optics, and a long lighting field may be formed in a different non-scanning direction from the scanning direction at the lighting process.
Moreover, at the rotation unsymmetrical aberration fluctuation reduction process, the astigmatism of the projection optics in the core of the exposure field may be amended.
Moreover, the projection optics may be equipped with a lens and may make mostly distribution of the exposure energy of the lens of the projection optics the symmetry of revolution at the rotation unsymmetrical aberration reduction process.
[Procedure amendment 5]
[Document to be Amended] Specification
[Item(s) to be Amended] 0077
[Method of Amendment] Modification
[The contents of amendment]
[0077]
[Effect of the Invention]
the rotation on the mask illuminated by the 1st illumination light since the 2nd illumination light is nonphotosensitivity to a photosensitive substrate according to the 1st and 4th projection aligner of this invention, and the projection exposure approach of this invention, although the 1st and 2nd illumination light is irradiated [both] on a photosensitive substrate -- the image of the pattern of an unsymmetrical exposure lighting field -- the rotation on a photosensitive substrate -- an unsymmetrical exposure lighting field imprints. moreover, rotation according to the 1st illumination light by the 2nd illumination light -- an unsymmetrical exposure lighting field is complemented, and in order to illuminate projection optics by the illumination light which passed through the exposure lighting field almost symmetrical with rotation, the symmetry-of-revolution nature of the exposure energy distribution to the lens of projection optics increases. therefore, rotation -- heat deformation of the lens by distribution of unsymmetrical heat energy, and rotation of a refractive index -- unsymmetrical distribution decreases and there is an advantage whose aberration fluctuation of projection optics decreases.

[Translation done.]

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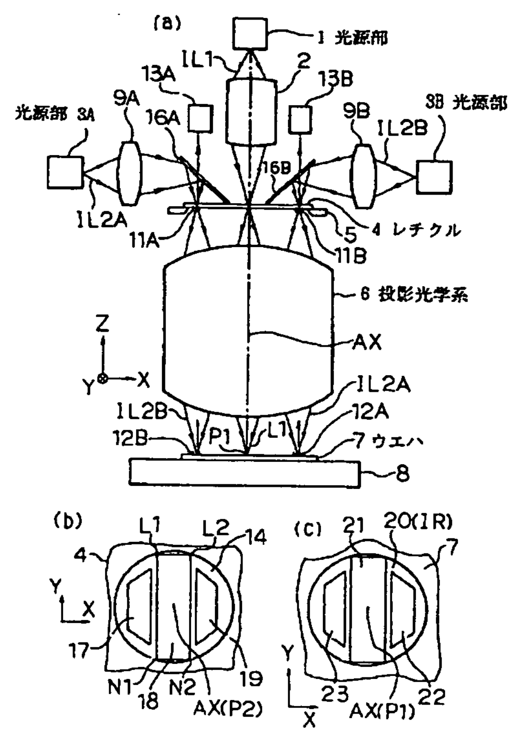
(54)【発明の名称】　投影露光装置

(57)【要約】
【課題】　レチクル上の回転非対称な領域のパターンを投影光学系を介してウエハ上の転写する場合の投影光学系の収差変動を少なくする。
【解決手段】　露光用の光源部１とは別にウエハ７上のフォトレジストを感光しない波長の照明光ＩＬ２Ａ，ＩＬ２Ｂを射出する光源部３Ａ，３Ｂを設ける。光源部１からの照明光ＩＬ１をレチクル４上の長方形の照明領域１８に照射し、光源部３Ａ，３Ｂからの照明光ＩＬ２Ａ，ＩＬ２Ｂをそれぞれミラー１６Ａ，１６Ｂを介して、レチクル４上の照明領域１８の左右の照明領域１７，１９に照射する。これにより投影光学系６のレンズに入射する照射エネルギー分布の偏りが減少し、そのレンズの回転非対称な熱変形等に伴う収差変動が少なくなる。照明光ＩＬ２Ａ，ＩＬ２Ｂはアライメントセンサ１３Ａ，１３Ｂの照明光としても利用する。



【特許請求の範囲】

【請求項１】　マスクに形成された所定の転写用パターンを感光性基板上に投影する投影光学系と、
前記投影光学系の光軸と前記感光性基板の被露光面とが交わる第１の点に対して回転対称な所定の円形露光領域内において、前記第１の点に対し回転非対称な露光照明領域を形成して回転非対称なマスクパターン像を前記感光性基板上に転写するために、前記感光性基板を感光させる波長を持つ第１照明光を供給し、前記投影光学系の光軸と前記マスクのパターン面とが交わる第２の点に対して前記マスクのパターン面内で回転非対称な露光照明領域を形成する第１の照明系と、前記投影光学系を介して前記感光性基板に向けて非感光性の波長を持つ第２照明光を供給し、前記第１照明光を伴って前記所定の円形露光領域内のほぼ全体を照明するように、前記感光性基板の被露光面内での前記回転非対称な露光照明領域を補完する非露光照明領域を前記所定の円形露光領域内に形成する第２照明系と、を有することを特徴とする投影露光装置。

【請求項２】　マスクに形成された所定の転写用パターンを感光性基板上に投影する投影光学系と、
前記感光性基板を感光させる波長を持つ第１照明光を供給する第１光源部と、
前記感光性基板に対して非感光性の波長を持つ第２照明光を供給する第２光源部と、
前記第１照明光と前記第２照明光とを合成して前記マスクへ導く合成系と、
該合成系と前記マスクとの間の光路上で、前記マスクのパターン面と実質的に共役となる位置に配置された視野絞りと、を設け、
前記視野絞りは、前記第１照明光を透過させる第１の透過部と前記第２照明光を透過させる第２の透過部とを有し、
前記第１の透過部は、前記投影光学系の光軸と前記マスクのパターン面とが交わる所定の点に対して回転対称な所定の円形領域内において、前記所定の点に対し回転非対称な露光照明領域としての第１の領域と共役であり、
前記第２の透過領域は、前記第１照明光を伴うことによって前記回転対称な所定の円形領域内のほぼ全体を照明するように、前記回転非対称な第１の領域を補完する被露光照明領域としての第２の領域と共役であることを特徴とする投影露光装置。

【請求項３】　請求項１、又は２記載の投影露光装置であって、
前記第２照明光が照明する領域に位置する前記マスク上のマスクマークと前記第２照明光が照明する領域に位置する前記感光性基板上の基板マークとの少なくとも一方からの光を光電的に検出し、双方のマークの内の少なくとも一方のマークの位置を検出するマーク位置検出系を有することを特徴とする投影露光装置。

【請求項４】　請求項１、２、又は３記載の投影露光装置であって、
前記回転対称な所定の円形露光領域、又は前記回転対称な所定の円形領域と共役な前記感光性基板上の領域は、前記投影光学系の前記感光性基板側の視野と一致することを特徴とする投影露光装置

【請求項５】　マスクに形成された所定の転写用パターンを感光性基板上に投影する投影光学系と、
前記感光性基板を感光させる波長を持つ照明光で前記マスクを照明する照明光学系と、
前記投影光学系と前記感光性基板との間に配置され、所定の光透過部を持つ光制限部材と、を設け、
該光制限部材の光透過部を通過した前記照明光は、前記投影光学系の光軸と前記感光性基板の被露光面とが交わる所定の点に対して回転対称な所定の円形露光領域内において、前記所定の点に対し回転非対称な領域に入射することを特徴とする投影露光装置。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、例えば半導体素子、液晶表示素子、撮像素子（ＣＣＤ等）、又は薄膜磁気ヘッド等を製造するためのフォトリソグラフィ工程でマスク上のパターンを感光性の基板上に露光するために使用される投影露光装置に関し、特にマスク上の転写用のパターン中のスリット状のような回転非対称な領域のパターンを基板上に投影した状態で、マスクと基板とを投影光学系に対して同期走査して露光を行うステップ・アンド・スキャン方式等の走査露光型の投影露光装置に適用して好適なものである。

【０００２】

【従来の技術】従来、半導体素子等を製造するために、マスクとしてのレチクル（又はフォトマスク等）上のほぼ正方形状の照明領域内のパターンを投影光学系を介して、感光性の基板としてのフォトレジストが塗布されたウエハ（又はガラスプレート等）上に露光するステッパー等の一括露光型の投影露光装置が多用されてきた。これに対して最近は、半導体素子等のチップパターンの大型化に対応するために、より大きな面積のレチクルのパターンをウエハ上の各ショット領域に転写することが求められている。ところが、広い有効露光フィールド（視野）の全面でディストーションや像面湾曲等の収差を所定の許容値以下に抑制した投影光学系の設計及び製造は困難である。

【０００３】そのため、最近ではレチクル上の長方形又は円弧状等のスリット状の照明領域内のパターンを投影光学系を介してウエハ上に投影した状態で、レチクルとウエハとを投影光学系に対して同期走査しながらレチクルのパターンをウエハ上の各ショット領域に逐次露光するステップ・アンド・スキャン方式等の走査露光型の投影露光装置が注目されている。この走査露光型の投影露

光装置は、投影光学系の有効露光フィールドの直径を最大限に利用できるほか、走査方向への転写パターンの長さはその有効露光フィールドの直径よりも長くできるため、結果として大面積のレチクルのパターンを小さい収差でウエハ上に転写できる。

【０００４】

【発明が解決しようとする課題】一般に投影露光装置においては、露光に際し、投影光学系のレンズに対して高いエネルギーを有する照明光が照射される。そのため、投影光学系のレンズを構成する硝材の照射エネルギーの吸収率が僅かに０．２％／ｃｍ程度であっても、照明光がレンズ上に光軸に関して回転非対称性を有した状態で照射された場合、照射エネルギーの吸収熱によりレンズの温度分布が変化することによってレンズが回転非対称に熱変形したり、部分的な温度上昇により硝材の屈折率分布が回転非対称に変動する。これにより、投影光学系の収差が徐々に悪化するというような、回転非対称性を有する不均一な照度分布の照明光の照射による投影光学系の収差変動が生じる。このような収差変動は、今日のような高解像力、且つ高い露光精度が要求される条件下では容認できない状態となってきた。

【０００５】従来は、このような投影光学系の収差の変動に対しては、投影光学系を例えば３つのブロックに分け、夫々のブロックを密閉して各ブロック内のレンズに接する気体の圧力を制御することで対処してきた。この方法では、ほぼ正方形の照明領域を使用する一括露光型の場合には、その照明領域の回転非対称性の程度が低いため、収差変動は充分に補正されてきた。しかし、走査露光型の投影露光装置のように、レチクル上の照明領域を長方形又は円弧状等のスリット状にするというような著しく光軸に関し回転非対称な照明領域を使用する場合には、そのような気圧制御を行っても、ディストーションや像面湾曲等の収差の変動が許容値以内に収まらない恐れがでてきた。特に回転非対称性が著しいときは、投影光学系の露光フィールドの中心でメリジオナル方向のパターンの最良像面と、それと垂直な方向のパターンの最良像面とが光軸方向に離れるというような非点収差が生じるという不都合もある。

【０００６】本発明は斯かる点に鑑み、レチクル上の回転非対称な領域のパターンを投影光学系を介してウエハ上に転写する場合に、投影光学系の収差変動の少ない投影露光装置を提供することを目的とする。

【０００７】

【課題を解決するための手段】本発明による第１の投影露光装置は、例えば図１に示すように、マスク（４）に形成された所定の転写用パターンを感光性基板（７）上に投影する投影光学系（６）と、その投影光学系の光軸（ＡＸ）とその感光性基板（７）の被露光面とが交わる第１の点（Ｐ１）に対して回転対称な所定の円形露光領域（２０）内において、その第１の点（Ｐ１）に対し回転非対称な露光照明領域（２１）を形成して回転非対称なマスクパターン像をその感光性基板（７）上に転写するために、その感光性基板（７）を感光させる波長を持つ第１照明光（ＩＬ１）を供給し、その投影光学系（６）の光軸とそのマスク（４）のパターン面とが交わる第２の点（Ｐ２）に対してそのマスク（４）のパターン面内で回転非対称な露光照明領域（１８）を形成する第１の照明系（１，２）と、その投影光学系（６）を介してその感光性基板（７）に向けて非感光性の波長を持つ第２照明光（ＩＬ２Ａ，ＩＬ２Ｂ）を供給し、その第１照明光（ＩＬ１）を伴ってその所定の円形露光領域（２０）内のほぼ全体を照明するように、その感光性基板（７）の被露光面内でのその回転非対称な露光照明領域（２１）を補完する非露光照明領域（２２，２３）をその所定の円形露光領域（２０）内に形成する第２照明系（３Ａ，３Ｂ，９Ａ，９Ｂ，１６Ａ，１６Ｂ）と、を有するものである。

【０００８】この場合、その第２照明光（ＩＬ２Ａ，ＩＬ２Ｂ）は投影光学系（６）を構成するレンズの硝材に或る程度は吸収される必要がある。但し、レンズの硝材で吸収される代わりに、レンズのコーティング膜で吸収されてもよい。斯かる本発明の第１の投影露光装置によれば、第２照明光（ＩＬ２Ａ，ＩＬ２Ｂ）も第１照明光（ＩＬ１）と同様に感光性基板（７）上に照射されるが、第２照明光（ＩＬ２Ａ，ＩＬ２Ｂ）は感光性基板（７）に対して非感光性であるため、第１照明光（ＩＬ１）により照明されるマスク（４）上の回転非対称な露光照明領域（１８）のパターンの像だけが感光性基板（７）上の回転非対称な露光照明領域（２１）に転写される。また、感光性基板（７）上の回転非対称な露光照明領域（２１）を補完して回転対称な円形露光領域（２０）を形成する被露光領域（２２，２３）を、第２照明光（ＩＬ２Ａ，ＩＬ２Ｂ）により照明するため、投影光学系（６）のレンズへの照射エネルギー分布の回転対称性が増加する。従って、投影光学系（６）のレンズの回転非対称な熱変形が減少し、回転非対称な屈折率分布も減少するため、投影光学系（６）の収差の変動が少なくなる。

【０００９】また、本発明による第２の投影露光装置は、例えば図２に示すように、マスク（４）に形成された所定の転写用パターンを感光性基板（７）上に投影する投影光学系（６）と、その感光性基板（７）を感光させる波長を持つ第１照明光（ＩＬ１）を供給する第１光源部（１，４１）と、その感光性基板（７）に対して非感光性の波長を持つ第２照明光（ＩＬ２Ａ）を供給する第２光源部（３Ａ，４７）と、その第１照明光（ＩＬ１）とその第２照明光（ＩＬ２Ａ）とを合成してそのマスク（４）へ導く合成系（４２，４４，４６）と、この合成系とそのマスク（４）との間の光路上で、そのマスク（４）のパターン面と実質的に共役となる位置に配置

された視野絞り（４８）と、を設け、その視野絞り（４８）は、その第１照明光（ＩＬ１）を透過させる第１の透過部（５０）と第２照明光（ＩＬ２Ａ）を透過させる第２の透過部（４９，５１）とを有し、その第１の透過部（５０）は、その投影光学系（６）の光軸（ＡＸ）とそのマスク（４）のパターン面とが交わる所定の点に対して回転対称な所定の円形領域（４８）内において、その所定の点に対し回転非対称な露光照明領域としての第１の領域（５０）と共役であり、その第２の透過領域（４９，５１）は、その第１照明光（ＩＬ１）を伴うことによってその回転対称な所定の円形領域（４８）内のほぼ全体を照明するように、その回転非対称な第１の領域（５０）を補完する被露光照明領域としての第２の領域（４９，５１）と共役であるものである。

【００１０】斯かる本発明の第２の投影露光装置によれば、合成系（４２，４４，４６）により一旦合成された第１及び第２照明光（ＩＬ１，ＩＬ２Ａ）は視野絞り（４８）により、マスク（４）上の回転非対称な被露光照明領域（５０）、及びその回転非対称な被露光照明領域を補完する被露光照明領域（４９，５１）を領域を通過し、投影光学系（６）を経て感光性基板（７）上に照射される。この場合、第１照明光（ＩＬ１）は、視野絞り（４８）によりマスク（４）の回転非対称な被露光照明領域としての第１の領域（５０）と共役な第１の透過部（５０）だけを通過するため、感光性基板（７）上には、そのマスク（４）上のその第１の領域（５０）のパターンの像だけが転写される。

【００１１】一方、投影光学系（６）には、マスク（４）上の第１の領域（５０）を透過する第１照明光（ＩＬ１）と、その第１の領域を補完して実質的に回転対称な円形領域（４８）を形成するマスク（４）上の第２の領域（４９，５１）を透過する第２照明光（ＩＬ２Ａ）とが入射する。第１及び第２照明光（ＩＬ１，ＩＬ２Ａ）の全体の照射領域は実質的に回転対称な円形領域となるため、本発明の第１の投影露光装置と同様に、投影光学系（６）のレンズへの照射エネルギー分布の回転対称性が増加する。従って、投影光学系（６）の収差変動が少なくなる。また、本発明ではマスク（４）上の回転非対称な被露光照明領域に照射される第１照明光（ＩＬ１）の視野を規定するための光学系、及び第２照明光（ＩＬ２Ａ）のマスク（４）上での視野を規定するための光学系が不要となる。

【００１２】また、本発明の第１及び第２の投影露光装置において、その第２照明光（ＩＬ２Ａ）が照明する領域に位置するそのマスク（４）上のマスクマーク（１１Ａ，１１Ｂ）とその第２照明光（ＩＬ２Ａ）が照明する領域に位置するその感光性基板（７）上の基板マーク（１２Ａ，１２Ｂ）との少なくとも一方からの光を光電的に検出し、双方のマークの内の少なくとも一方のマークの位置を検出するマーク位置検出系（１３Ａ，１３Ｂ）を有することが好ましい。これにより、第２照明光（ＩＬ２Ａ）をマスク（４）又は感光性基板（７）の位置を検出するためのマーク位置検出系（１３Ａ，１３Ｂ）用の照明光として有効に利用できる。

【００１３】また、その回転対称な所定の円形露光領域（２０）、又はその回転対称な所定の円形領域（４８）と共役なその感光性基板（７）上の領域は、その投影光学系（６）の感光性基板（７）側の視野と一致することが好ましい。これにより、投影光学系（６）のレンズはほぼ回転対称でほぼ最大径の円形の照明領域により照明されるため、レンズへの照射エネルギーの分布が更に回転対称になる。

【００１４】また、本発明による第３の投影露光装置は、例えば図８に示すように、マスク（４）に形成された所定の転写用パターンを感光性基板（７）上に投影する投影光学系（６）と、その感光性基板（７）を感光させる波長を持つ照明光（ＩＬ１）でそのマスク（４）を照明する照明光学系（１Ａ，４１）と、その投影光学系（６）とその感光性基板（７）との間に配置され、所定の光透過部（７３）を持つ光制限部材（７１）と、を設け、この光制限部材の光透過部（７３）を通過したその照明光（ＩＬ１）は、その投影光学系（６）の光軸（ＡＸ）とその感光性基板（７）の被露光面とが交わる所定の点に対して回転対称な所定の円形露光領域（７１）内において、その所定の点に対し回転非対称な領域（７３）に入射するものである。

【００１５】斯かる本発明の第３の投影露光装置によれば、感光性基板（６）に対して感光性の照明光（ＩＬ１）は、マスク（４）及び投影光学系（６）の回転対称な領域を通過した後、光制限部材（７１）によりマスク（４）上の回転非対称な領域に対応する領域だけを通過して感光性基板（７）上に照射される。従って、マスク（４）上の回転非対称な領域のパターンの像だけが、感光性基板（７）上に転写される。また、照明光（ＩＬ１）によりマスク（４）上の回転対称な領域を照明するため、本発明の第１及び第２の投影露光装置と同様に、投影光学系（６）のレンズへの照射エネルギー分布の回転対称性が増加し、投影光学系（６）の収差変動が少なくなる。本発明では、特に１つの照明光（ＩＬ１）だけでマスク（４）を照明するため、投影光学系（６）のレンズ全体に一様な波長の光エネルギーが照射される。従って、それらレンズにおける熱エネルギーの吸収量も一様になり、レンズの回転非対称な熱変形が更に減少し、投影光学系（６）の収差の発生も更に抑えられる。また、１つの照明光（ＩＬ１）だけを使用するため、光源や照明光学系等の設備を節約できる。

【００１６】

【発明の実施の形態】以下、本発明の投影露光装置の実施の形態の第１の例につき図１を参照して説明する。本例はステップ・アンド・スキャン方式の投影露光装置に

本発明を適用したものである。図１（ａ）は、本例の投影露光装置の概略構成を示し、この図１（ａ）に示すように、本例にはレチクル４上のパターン領域を照明する３つの光源部１，３Ａ，３Ｂが設けられている。露光時には、光源部１からはウエハ７上に塗布されたフォトレジストに感光性の波長λ１の照明光ＩＬ１が射出され、光源部３Ａ，３Ｂからはウエハ７のフォトレジストに非感光性の波長λ２の照明光ＩＬ２Ａ，ＩＬ２Ｂが射出される。光源部１は、露光光源、レチクル４上の照度分布を均一にするためのフライアイレンズ、レチクル４上の照明領域を規定する視野絞り等を含んで構成され、光源部１から射出された照明光ＩＬ１は、照明光学系２を介してレチクル４上の非走査方向に長い長方形の照明領域１８（図１（ｂ）参照）に照射される。その照明光ＩＬ１のもとで、レチクル４の長方形の照明領域１８内のパターンの像が投影光学系６を介してフォトレジストが塗布されたウエハ７上に投影倍率β（βは例えば１／４又は１／５等）で転写される。以下、投影光学系６の光軸ＡＸに平行にＺ軸を取り、Ｚ軸に垂直な２次元平面内で図１（ａ）の紙面に平行にＸ軸、図１（ａ）の紙面に垂直にＹ軸を取って説明する。本例では走査露光時のレチクル４及びウエハ７の走査方向はＸ方向である。

【００１７】一方、非露光光の光源部３Ａ，３Ｂは、それぞれ光源、レチクル４上の照度分布を均一にするためのフライアイレンズ、及びレチクル４上での照明領域を規定する視野絞り等を含んで構成されている。そして、レチクル４の－Ｘ方向の上部に配置された光源部３Ａから射出された波長λ２の照明光ＩＬ２Ａは、コンデンサレンズ９Ａを透過し、照明光ＩＬ２Ａの入射方向に対して斜設された僅かな透過率を有するミラー１６Ａにより下方に反射されてレチクル４上の照明領域１７（図１（ｂ）参照）に集光される。また、レチクル４の＋Ｘ方向の上部に配置された光源部３Ｂから射出された波長λ２の照明光ＩＬ２Ｂは、コンデンサレンズ９Ｂを透過し、照明光ＩＬ２Ｂの入射方向に対して斜設された僅かな透過率を有するミラー１６Ｂにより下方に反射されてレチクル４上の照明領域１９に集光される。そして、レチクル４を透過した照明光ＩＬ２Ａ，ＩＬ２Ｂは、投影光学系６を介してウエハ７上に照射される。

【００１８】この場合、照明光ＩＬ２Ａの照明領域１７及び照明光ＩＬ２Ｂの照明領域１９は、それぞれ照明光ＩＬ１のレチクル４上の長方形の照明領域１８に対して走査方向に外側の領域になるように設定されている。照明光ＩＬ１の波長λ１及び照明光ＩＬ２Ａ，ＩＬ２Ｂの波長λ２は、フォトレジストの種類及び投影光学系６の硝材の種類により異なるが、通常の場合、波長λ１は５３０ｎｍ未満、波長λ２は５３０ｎｍ以上の波長を選択する。露光用の照明光ＩＬ１としては、水銀ランプのｉ線（波長３６５ｎｍ）やｇ線（波長４３６ｎｍ）等の輝線、ＡｒＦエキシマレーザ光（波長１９３ｎｍ）やＫｒＦエキシマレーザ光（波長２４８ｎｍ）等のエキシマレーザ光、あるいは銅蒸気レーザ光やＹＡＧレーザ光の高調波等が使用される。

【００１９】また、照明光ＩＬ２Ａ，ＩＬ２Ｂは投影光学系６の硝材に対する回転非対称な照射エネルギーの分布を抑える目的で使用されるため、硝材又はレンズのコーティング膜での単位面積当たりの光吸収量が全体として照明光ＩＬ１に近いものが好ましい。その意味から、照明光ＩＬ２Ａ，ＩＬ２Ｂとしては、フォトレジストを感光させない波長で、光の吸収率が小さいときには光源の光強度が強く、一方光源の光強度が小さいときには投影光学系６のレンズの硝材又はコーティング膜に対する光吸収率のできるだけ大きな波長を有するものが好ましい。好ましい例としては、例えばＨｅ－Ｎｅレーザからのレーザビーム（波長６３３ｎｍ）等が挙げられる。

【００２０】なお、投影光学系の硝材として、石英やガラス等が使用された場合、これらの硝材は、約２μm以上の長い波長でもかなりの光吸収率を有するので、照明光ＩＬ２Ａ，ＩＬ２Ｂとして、フッ化水素（ＨＦ）ガスの化学反応を利用したＨＦ化学レーザ光（波長２．４～３．４μｍ）等を使用してもよい。また、石英以外の光学ガラスは、不純物を含んでいるため、５３０ｎｍ以上の長い波長でも１％／ｃｍに近い光吸収率を有するものもあり、このような１％／ｃｍに近い光吸収率を有する照明光でも照射エネルギーの回転非対称な分布の対策としては十分有効である。このような照明光の例としては、水素（H_2）放電管からのＣ線（波長６５６．３ｎｍ）やヘリウム（Ｈｅ）放電管からのｄ線（波長５８７．６ｎｍ）等が挙げられる。

【００２１】次に、レチクル４は走査方向（Ｘ方向）に一定速度で移動自在で且つＸ方向及びＹ方向に微動可能なレチクルステージ５上に載置されている。レチクルステージ５の位置は外部のレーザ干渉計（不図示）により精密に計測されており、そのレーザ干渉計の測定値に基づいてレチクルステージ５の位置が制御されている。また、レチクル４上にはウエハ７との位置合わせ用のレチクルマーク１１Ａ，１１Ｂが形成されている。

【００２２】一方、ウエハ７は不図示のウエハホルダを介して走査方向（Ｘ方向）に一定速度で移動自在なウエハステージ８上に載置されている。ウエハステージ８はＸ方向及びＹ方向にステッピング移動もできるように構成されており、ウエハ７上の各ショット領域を投影光学系６の露光領域への走査開始位置に移動する動作と、走査露光動作とを繰り返すステップ・アンド・スキャン方式によりウエハ７上の各ショット領域にレチクル４のパターンの像が逐次転写される。走査露光時には、レチクル４が＋Ｘ方向（又は－Ｘ方向）へ、例えば速度V_Rでスキャンされるのと同期して、ウエハ７が－Ｘ方向（又は＋Ｘ方向）に速度$\beta \cdot V_R$（βは投影倍率）でスキャンされる。また、ウエハ７上の各ショット領域には位置

合わせ用のウエハマーク１２Ａ，１２Ｂが形成されている。

【００２３】次に、本例の露光動作について説明する。本例では、走査露光時にはレチクル４上のスリット状の照明領域だけでなく、それ以外のパターン領域も照明する。即ち、走査露光が開始されると同時に、３個の光源部１，３Ａ，３Ｂからそれぞれ照明光ＩＬ１，ＩＬ２Ａ，ＩＬ２Ｂが射出される。図１（ｂ）は、レチクル４上の照明光ＩＬ１，ＩＬ２Ａ，ＩＬ２Ｂの照明領域を示し、この図１（ｂ）において光源部１からの照明光ＩＬ１は、投影光学系６の有効露光フィールド（視野）と共役な円形の有効照明領域１４の外形と接する点Ｌ１，Ｌ２，Ｎ１，Ｎ２を結んだ長方形の照明領域１８に照射されている。この場合、円形の有効照明領域１４の中心Ｐ２は光軸ＡＸに一致している。一方、光源部３Ａからの照明光ＩＬ２Ａは照明領域１８の－Ｘ方向の点Ｌ１，Ｎ１を結んだ境界線から左外側の台形状の照明領域１７に照射されている。また、光源部３Ｂからの照明光ＩＬ２Ｂは照明領域１８の＋Ｘ方向の点Ｌ２，Ｎ２を結んだ境界線から右外側の台形状の照明領域１９に照射されている。即ち、照明領域１７，１９は回転非対称な長方形の照明領域１８を補完して円形の有効照明領域１４に近い照明領域を形成するための補完照明領域といえる。照明領域１８を透過した照明光ＩＬ１、及び照明領域１７，１９をそれぞれ透過した照明光ＩＬ２Ａ，ＩＬ２Ｂは、共に投影光学系６を透過してウエハ７上に照射される。

【００２４】図１（ｃ）は、ウエハ７上の照明領域を示し、この図１（ｃ）において、投影光学系６の有効露光フィールド（視野）ＩＲと一致する円形の有効露光領域２０の外周に内接する非走査方向（Ｙ方向）に長い長方形の露光領域２１にウエハ７のフォトレジストに感光性の照明光ＩＬ１が照射されている。この場合、円形の有効露光領域２０の中心Ｐ１は光軸ＡＸに一致している。そして、その長方形の露光領域２１を補完して円形の有効露光領域２０に近い照明領域を形成する照明領域２２，２３にそれぞれウエハ７のフォトレジストに非感光性の照明光ＩＬ２Ａ，ＩＬ２Ｂが照射されている。

【００２５】即ち、走査露光時にはレチクル４上で回転対称に近い領域が照明され、投影光学系６内のレンズもほぼ回転対称に照明されるため、レンズの硝材における照明光のエネルギーの吸収密度は回転対称に近い分布となる。従って、投影光学系６のレンズの回転非対称な熱変形等が抑えられ、投影光学系６の収差変動が抑えられる。この場合、その収差変動をできるだけ少なくするために、光源部３Ａ，３Ｂからのそれぞれの照明光ＩＬ２Ａ，ＩＬ２Ｂによるレチクル４上の照明領域１７，１９の合計面積は、有効照明領域１４内の照明光ＩＬ１による照明領域１８以外の面積の１／２以上であることが望ましい。

【００２６】また、レチクル４上の照明領域１７，１９を透過した照明光ＩＬ２Ａ，ＩＬ２Ｂがそれぞれウエハ７上の照明領域２２，２３にも照射されるが、照明光ＩＬ２Ａ，ＩＬ２Ｂはウエハ７上のフォトレジストに非感光性であるため、ウエハ７上にはレチクル４上の照明領域１８内のパターンの像だけが転写される。また、本例では光源部３Ａ，３Ｂからの照明光ＩＬ２Ａ，ＩＬ２Ｂをレチクル４とウエハ７との位置合わせのためのアライメントセンサの検出光としても使用する。そのため、レチクル４のＸ方向の両端部の上方に、ＴＴＲ方式で画像処理方式のアライメントセンサ１３Ａ，１３Ｂを設置し、光源部３Ａ，３Ｂから射出された照明光ＩＬ２Ａ，ＩＬ２Ｂを、それぞれレチクル４上のレチクルマーク１１Ａ，１１Ｂが形成された位置を含む領域に照射する。そして、アライメントセンサ１３Ａ，１３Ｂを用いてウエハマーク１２Ａ，１２Ｂとレチクルマーク１１Ａ，１１Ｂとの相対的な位置ずれを検出する。この場合には、アライメントセンサ用の光源を設ける必要がなく効率的である。なお、アライメントセンサ１３Ａ，１３Ｂはレチクルマーク１１Ａ，１１Ｂとウエハマーク１２Ａ，１２Ｂとをそれぞれ別々に検出するアライメントセンサでもよい。

【００２７】次に、本発明の実施の形態の第１の例の変形例について、図７を参照して説明する。本変形例は、図１の光源部３Ａ，３Ｂからの照明光をレチクル４の下部側から直接投影光学系６に入射させるように構成したものである。その他の構成は第１の例と同様であり、図７において図１と対応する部分には同一符号を付し、その説明を省略する。

【００２８】図７（ａ）は、本変形例の投影露光装置の概略構成を示し、この図７（ａ）において、レチクル４の下部の左右に図１と同様に波長λ２の照明光ＩＬ２Ａ，ＩＬ２Ｂを射出する光源部３Ａ，３Ｂが設置されている。光源部３Ａからの照明光ＩＬ２Ａは、コンデンサレンズ９Ａを透過し、照明光ＩＬ２Ａの入射方向に対して斜設されたミラー３３Ａにより下方に反射されて投影光学系６に入射する。もう１つの光源部３Ｂからの照明光ＩＬ２Ｂも同様にコンデンサレンズ９Ｂを透過し、照明光ＩＬ２Ｂの入射方向に対して斜設されたミラー３３Ｂにより下方に反射されて投影光学系６に入射する。以下は第１の例と同様である。

【００２９】図７（ｂ）は、レチクル４上における照明領域を示し、この図７（ｂ）において、光源部１からの照明光ＩＬ１は、円形の有効照明領域１４の外形に内接する長方形の照明領域１８に照射されている。一方、光源部３Ａ，３Ｂからのそれぞれの照明光ＩＬ２Ａ，ＩＬ２Ｂはレチクル４上には照射されないが、ミラー３３Ａ，３３Ｂで光路を折り返したレチクル４上の仮想的な照明領域は、それぞれ点線で示す台形状の照射領域１７Ａ，１７Ｂとなる。従って、第１の例と同様に、投影光学系６のレンズの照射エネルギーの分布はほぼ回転対称

となり、投影光学系６の収差変動を低減することができる。

【００３０】本変形例は、スペース面や配置上の制約から第１の例のように、レチクル４の入射側に、ミラー１６Ａ，１６Ｂを配置できない場合に有効な方法である。但し、本変形例の場合はミラー３３Ａ，３３Ｂによる照明光ＩＬ１のケラレのために、レチクル４上における照明光ＩＬ１の照明領域１８と、光源部３Ａ，３Ｂからの照明光ＩＬ２Ａ，ＩＬ２Ｂによる仮想的な照明領域１７Ａ，１９Ａとの境界を、明確に区別することが困難であることがある。

【００３１】次に、本発明による実施の形態の第２の例について、図２を参照して説明する。本例は、２つの光源部を設置し、合成光学系及び波長選択性を有する視野絞り等を利用して投影光学系内にほぼ回転対称なエネルギー分布を有する照明光を供給するものである。基本的な構成は第１の例と同様であり、図２において図１と対応する部分には同一符号を付し、その詳細説明を省略する。なお、図２ではウエハステージ等は省略している。

【００３２】図２は、本例の投影露光装置の概略構成を示し、この図２において、光源部１から射出されたウエハ７上のフォトレジストに感光性の波長λ１の照明光ＩＬ１は、リレーレンズ４１により平行光束となり、照明光ＩＬ１の光路に対して斜設された偏光ビームスプリッタ４２を透過してコンデンサレンズ４６に入射する。なお、本例の照明光ＩＬ１及びＩＬ２Ａはそれぞれ P偏光に直線偏光して偏光ビームスプリッタ４２に入射するものとする。もう一方の光源部３Ａから射出されたウエハ７上のフォトレジストに非感光性の波長λ２の照明光ＩＬ２Ａも、リレーレンズ４７により平行光束となり、照明光ＩＬ１と直交する方向から偏光ビームスプリッタ４２に入射する。照明光ＩＬ２Ａは偏光ビームスプリッタ４２を透過し、１／４波長板４３を経てミラー４４により反射され、再び１／４波長板４３を経てＳ偏光として偏光ビームスプリッタ４２に入射する。Ｓ偏光となった照明光ＩＬ２Ａは偏光ビームスプリッタ４２により反射され、先に説明した照明光ＩＬ１と合成されて照明光ＩＬ３としてコンデンサレンズ４６に入射し、コンデンサレンズ４６を介してレチクル４上に照射される。また、偏光ビームスプリッタ４２とコンデンサレンズ４６との間には１／４波長板４５が設置され、照明光ＩＬ３はほぼ円偏光の状態でレチクル４に照射される。これによって、レチクル４のパターンの方向が変わっても良好な転写が行われる。

【００３３】レチクル４の上面には、近接して波長選択性を有する視野絞り４８が設置されており、この視野絞り４８により、照明光ＩＬ３を構成する照明光ＩＬ１及び照明光ＩＬ２Ａのレチクル４上におけるそれぞれの照明領域が決定される。視野絞り４８は、波長選択性を有する２種類の光学フィルターから構成されている。図２（ｂ）は、視野絞り４８の平面図を示し、この図２（ｂ）において、視野絞り４８の中央には、波長λ１の光束を選択的に透過する非走査方向に長い長方形の光学フィルター５０が設けられている。本例では視野絞り４８はレチクル４と近接しているため、この光学フィルター５０の形状がそのままレチクル４上の照明光ＩＬ１の照明領域とみなせる。また、視野絞り４８上の光学フィルター５０の左右に波長λ２の照明光ＩＬ２Ａを選択的に透過する半円状の光学フィルター４９，５１が設けられている。そして、光学フィルター５０及び光学フィルター４９，５１は全体として光軸ＡＸを中心とする円形領域を形成しており、この円形領域はレチクル４上の有効照明領域に収まる領域である。

【００３４】これらの光学フィルター４９～５１が設けられた視野絞り４８を通過した照明光ＩＬ１，ＩＬ２Ａは、レチクル４を透過した後、更に投影光学系６を通過してウエハ７上に照射されるが、照明光ＩＬ２Ａはウエハ７上のフォトレジストに非感光性であるため、ウエハ７上には光学フィルター５０の形状で規定されるレチクル４上のパターンの像だけが転写される。

【００３５】また、光源部１から射出された照明光ＩＬ１と光源部３Ａから射出された照明光ＩＬ２Ａとを同時に投影光学系６に入射させることによって、投影光学系６内の硝材の吸収エネルギーは、光軸ＡＸに対し回転対称に近い密度分布になって、収差変動が少なくなる。また、従来例のように、投影光学系６の硝材の熱変形が著しく回転非対称である場合は、投影光学系の露光フィールドの中心でメリジオナル方向のパターンの最良像面と、それと垂直な方向のパターンの最良像面とが光軸方向に離れるというような非点収差（以下、「中心アス」という）が生じることがある。しかし、本例ではこのような中心アス等の回転非対称な収差変動の発生も抑えられる。また、本例の方法は以下のように円弧状の露光領域を用いる場合に特に有効である。

【００３６】図２（ｃ）は、露光領域として円弧状の露光領域を用いる場合に視野絞り４８の代わりに使用する視野絞りの状態を示し、この図２（ｃ）において、視野絞り４８Ａの中央には光源部１からの照明光ＩＬ１を選択的に透過する円弧状の光学フィルター５０Ａが配置され、視野絞り４８Ａ上の光学フィルター５０Ａの左右に波長λ２の照明光ＩＬ２Ａを選択的に透過する半円状光学フィルター４９Ａ及び三日月状の光学フィルター５１Ａが設けられている。これらの光学フィルター４９Ａ，５１Ａ及び５０Ａの形状は、全体として光軸ＡＸを中心とする円形領域を形成するように設定されている。本例では、レチクル４上で円弧状の光学フィルター５０Ａの内部のパターンが投影光学系６を介してウエハ７上に投影される。しかも、投影光学系６にはほぼ光軸ＡＸを中心として回転対称の照射エネルギーが供給され、収差変動が少なくなる。

【００３７】このように円弧状の照明領域の場合、第１の例において投影光学系６内の硝材に対して回転対称な照射エネルギーを与えるためには、光源部１，３Ａ，３Ｂ内の視野絞りを極めて複雑な形状に設定する必要があり、製造コストが増大する。しかし本例によれば、そのレチクル４上の円弧状の照明領域に合わせて光学フィルター５０Ａの形状を設定すればよく、しかもそれに合わせて容易に照明光ＩＬ２Ａの光学フィルター４９Ａ，５１Ａの形状も設定できる。

【００３８】なお、図２（ｂ）の光学フィルター５０としては、光源部３Ａからの照明光ＩＬ２Ａに対する透過率の出来るかぎり小さいものが、投影光学系６内の回転非対称な照射エネルギー分布による収差変動を低減する効果が大きく望ましい。また、投影光学系６の収差変動をできるだけ少なくするためには、光学フィルター４９，５１の面積は、光学フィルター５０に外接する円内のうち、光学フィルター５０以外の部分の面積の少なくとも１／２以上であることが望ましい。

【００３９】また、図２（ａ）の例においては、視野絞り４８はレチクル４のパターン面の近傍に設定されているが、視野絞り４８をレチクル４のパターン面と共役な面に配置してもよい。なお、図２（ａ）において、合成光学系として偏光ビームスプリッタ４２の代わりに２点鎖線で示すようにダイクロイックミラーＤＭを用いてもよい。このダイクロイックミラーＤＭは照明光ＩＬ１を透過して照明光ＩＬ２Ａを反射する波長選択性を有し、これによって両照明光ＩＬ１，ＩＬ２Ａが無駄なく合成される。また、この際には１／４波長板４５は不要である。

【００４０】次に、本発明の投影露光装置の実施の形態の第３の例について、図８を参照して説明する。本例は、１つの光源だけを使用し、投影光学系とウエハとの間に遮光板を設けたものであり、図８において図１又は図２と対応する部分には同一符号を付し、その詳細説明を省略する。図８（ａ）は、本例の投影露光装置の概略構成を示し、この図８（ａ）において、光源部１Ａから射出されたフォトレジストに対して感光性の照明光ＩＬ１は、コンデンサレンズ４１によりレチクル４上に照射される。この場合、照明光ＩＬ１のレチクル４上での照明領域形状は、図１の照明領域１８のように長方形には整形されておらず、投影光学系６の有効露光フィールドと共役な円形の有効照明領域となっている。レチクル４上の円形の有効照明領域を通過した照明光ＩＬ１は、投影光学系６を透過し、ウエハ７に近接して配置された遮光板７１に入射する。

【００４１】図８（ｂ）は、遮光板７１の平面図を示し、この図８（ｂ）において、遮光板７１の中心は光軸ＡＸに一致している。遮光板７１の中央部には、光軸ＡＸを中心とするＹ方向に長い長方形の透過領域７３が設けられており、その透過領域７３を囲むように遮光帯７２が設けられている。遮光板７１に入射した照明光ＩＬ１の内で透過領域７３を透過した照明光のみがウエハ７上に照射される。これにより、ウエハ７上には、遮光板７１の透過領域７３に対応するレチクル４上のＹ方向に長い長方形の領域のパターンの像が転写される。

【００４２】本例によれば、投影光学系６とウエハ７との間に遮光板７１を設けるだけで、レチクル４上の所望の回転非対称な領域のパターンの像だけを転写できる。そのため、照明光ＩＬ１の照明領域を整形するための照明光学系の構成が簡単になる。また、１つの光源部１Ａだけを使用するため、図１、図２、図７の例に比較して光源部やコンデンサレンズ等の設備が節約できる。また、遮光板７１を設けるだけでよいため、構成が極めて簡単で調整等の作業も容易に行える。特に、本例では１つの光源部１Ａからの照明光ＩＬ１によりレチクル４及び投影光学系６の回転対称な領域を照明するため、投影光学系６の硝材の光エネルギーの吸収密度分布は更に光軸ＡＸの周りに回転対称となり、硝材の熱変形に伴う投影光学系６の収差の発生が更に抑えられる。

【００４３】なお、遮光板７１を入れ換えるための交換機構を設け、透過領域の形状を露光領域に合わせて形成した複数の遮光板をその交換機構を介して交換するように構成してもよい。また、透過領域７３を任意な形状に変更可能な視野調整機構を遮光板７１の代わりに設けてもよい。なお、図８の例において、機構的な都合でウエハ７と遮光板７１との間に有限の距離ｄ１が存在して、遮光板７１によるケラレによってウエハ７上での照明むらが問題となる場合においては、図９（ａ）で示すようにウエハ７上での露光光の最大開口数（ＮＡ）を$\sin\theta$とすると、レチクル４の付近又はレチクル４よりも光源側のレチクル４の共役位置に、図９（ｂ）で示すようなウエハ７の露光領域と共役な領域８１の外側に、幅$d_R = 2\beta \cdot d1 \cdot \tan\theta$（$\beta$は１／４，１／５等の投影倍率）の遮光帯８４，８５を設けた部材８０を配置するとよい。この場合、図８（ａ）の照明光ＩＬ１は遮光帯８４，８５を除く領域８１，８２，８３を通過する。

【００４４】それにより図９（ａ）において、幅d_Rの遮光帯８５とウエハ７上で共役な位置７Ａから７Ｂまでの領域においては露光が全くされず、遮光板７１の透過領域７３と遮光帯７２との境界を位置７Ａと７Ｂとの中間位置７Ｃの上方に配置し、他方の遮光帯８４についても同様にすれば、遮光板７１によるケラレは起こらない。遮光帯８４，８５の幅d_Rが円形の部材８０の直径よりも十分小さい場合、図８（ａ）の投影光学系６のレンズはほぼ回転対称に照明され、回転非対称な収差変動は十分に補正される。

【００４５】次に、上述の実施の形態における投影光学系の収差変動の低減の効果を計算例に基づいて説明する。先ず、照明エネルギーによる温度分布の上昇を計算する。そのため、図１の例において、投影光学系６のレ

ンズを円筒形に近似して、レンズの側面から空気を通して熱が流出せずレンズの縁が金属と接することにより、そのレンズの縁からのみ熱が流出するものと仮定する。そのレンズの半径方向の距離をｒ、光軸ＡＸの回りの角度をφ、上昇後の温度分布をＴ（ｒ，φ）、レンズの単位体積当たりの熱吸収量をω（ｒ，φ）、熱伝導率をλ、レンズの外半径をａとすると、熱平衡状態での円筒座標系（ｒ，φ）での熱伝導方程式は、次式のようになる。

【００４６】

【数１】

$$\partial^2 T/\partial r^2+(1/r)\cdot\partial T/\partial r+(1/r^2)\cdot\partial^2 T/\partial\phi^2+\omega(r,\phi)/\lambda=0$$

【００４７】そこで、（数１）の熱伝導方程式を解くと、次式のようになる。

【００４８】

【数２】

$$T(r,\phi)=\sum_{i=1}^{\infty}\sum_{n=0}^{\infty}C_{in}\cdot J_0(p_{in}\cdot r)\cos(n\phi)+\sum_{i=1}^{\infty}\sum_{n=0}^{\infty}S_{in}\cdot J_0(p_{in}\cdot r)\sin(n\phi)$$

【００４９】ここで、$J_n(p_{in}\cdot r)$は、第１種第ｎ次（ｎ＝０，１，２，…）のベッセル(Bessel)関数で、p_{in}（ｉ＝１，２，…）は、$J_n(p_{in}\cdot a)=0$を満たす数列である。また、係数C_{in}は次式により表される。

【００５０】

【数３】

$$C_{in}=\int_0^a\int_0^{2\pi}(\omega(r,\phi)/\lambda)\cdot J_0(p_{in}\cdot r)\cdot\cos(n\phi)\cdot r\,dr\,d\phi\Big/\{(\pi/2)\cdot p_{in}^2\cdot a^2[J_{n+1}(p_{in}\cdot a)]^2\}$$

【００５１】但し、ｎ＝０のときのみ、係数C_{in}は次式により求められる。

【００５２】

【数４】

$$C_{in}=\int_0^a\int_0^{2\pi}(\omega(r,\phi)/\lambda)\cdot J_0(p_{i0}\cdot r)\cdot r\,dr\,d\phi\Big/\{\pi\cdot p_{i0}^2\cdot a^2[J_1(p_{i0}\cdot a)]^2\}$$

【００５３】また、係数S_{in}は次式により表される。

【００５４】

【数５】

$$S_{in}=\int_0^a\int_0^{2\pi}(\omega(r,\phi)/\lambda)\cdot J_0(p_{in}\cdot r)\cdot\sin(n\phi)\cdot r\,dr\,d\phi\Big/\{(\pi/2)\cdot p_{in}^2\cdot a^2[J_{n+1}(p_{in}\cdot a)]^2\}$$

【００５５】次に、温度分布の上昇によりどの次数の収差変動が多く現れるかを調べるために、上昇後の温度分布Ｔ（ｒ，φ）を以下のように最小２乗法でフーリエ・ベキ級数展開する。ここで、上昇後の温度分布Ｔ（ｒ，φ）の単位は℃で、距離ｒの単位はｍｍである。

【００５６】

【数６】

$$T(r,\phi)=\sum_{i=0}^{\infty}\sum_{n=0}^{\infty}B_{in}\cdot r^{i+n}\cdot\cos(n\phi)$$

【００５７】但し、ｉ＝０，２，４，６，…である。ここで、ｉ＝０，ｎ＝０の場合の級数B_{00}は、光軸ＡＸ、即ちｒ＝０での上昇温度になる。以下、実際の数値に基づいて第１の例における効果を第１及び第２の２つの計算例により説明する。第１の計算例ではレチクル上の露光光の照明領域として長方形の照明領域を使用し、第２の計算例では円弧状の照明領域を使用する。この場合、投影光学系６のレンズをレンズ６１で代表し（図３～図６参照）、レンズ６１を外半径ａが４０ｍｍの円筒形の石英であるとする。石英の場合、熱伝導率は、０．０１３８Ｗ／（ｃｍ・℃）である。また、ウエハ７のフォトレジストを感光する波長λ１の照明光ＩＬ１に対するレンズ６１の熱吸収率を２％／ｃｍとする。

【００５８】第１の計算例において、先ず比較のため、図１のレチクル４上の７０ｍｍ×１６．８ｍｍの長方形の照明領域１８だけに照明光ＩＬ１が照射される場合について計算する。この場合、上記（数３）、（数４）、及び（数５）の熱吸収量ω（ｒ，φ）に長方形の吸収エネルギー密度を代入して、その結果を（数２）に代入した場合の熱伝導方程式の解に基づいて計算する。

【００５９】図３（ａ）は、長方形の照明領域だけに照明光ＩＬ１が照射された場合のレンズ６１上の照射状態

を示し、この図３（ａ）において、図１（ｂ）の照明領域１８の点Ｌ１，Ｌ２，Ｎ１，Ｎ２に対応する点Ｌ１’，Ｌ２’，Ｎ１’，Ｎ２’で囲まれた長方形の照明領域６２の走査方向の幅ＤＸ及び非走査方向の幅ＤＹをそれぞれ１６．８ｍｍ、及び７０ｍｍとする。そして、その照明領域６２は照明光ＩＬ１により一様に照射されているものとし、単位時間当たりの全照射量を１Ｗとする。

【００６０】図３（ｂ）は、以上の計算結果を図に表したものであり、横軸及び縦軸はそれぞれ光軸ＡＸから走査方向への距離ｘ及び非走査方向への距離ｙを表す。この図３（ｂ）において、レンズ６１上の温度分布を温度差０．０２℃毎の等温線６３Ａで示す。なお、温度は内側から外側に向けて低い値となっている。なお、以下説明する図４（ｂ）～図６（ｂ）においても、横軸及び縦軸はそれぞれ光軸ＡＸから走査方向への距離ｘ及び非走査方向への距離ｙを表し、等温線６３Ｂ～６３Ｄは内側から外側に向かって低下する温度差０．０２℃毎の等温線を示している。

【００６１】この図３（ｂ）の光軸ＡＸを中心とする非走査方向に長い楕円状の等温線６３Ａに示すように、レンズ６１上の長方形の照明領域６２に照明光ＩＬＩが照射されているだけの場合は、レンズ６１上の光軸ＡＸから離れた位置では、回転対称に近い温度分布となっているが、光軸ＡＸ（ｘ＝０，ｙ＝０）の近くでは回転非対称な温度分布となっている。

【００６２】表１は、上記（数６）によって、フーリエ・ベキ級数展開した級数B_{in}を示し、横欄にｎ（０，１，２，…）、縦欄にｉ（＝０，２，４，…）を取り、それぞれのｎ，ｉの値に対応する級数B_{in}の値が示されている。表１については後で説明する。なお、後述する表２～表４も表１と同様に級数B_{in}の値が示されている。

【００６３】

【表１】

	n=0	n=1	n=2	n=3	n=4
i=0	2.2045×10^{-1}	0.0000	-2.4550×10^{-4}	0.0000	1.4452×10^{-7}
i=2	-3.4345×10^{-4}	0.0000	6.3423×10^{-7}	0.0000	-3.3489×10^{-10}
i=4	3.9964×10^{-7}	0.0000	-8.4516×10^{-10}	0.0000	3.1901×10^{-13}
i=6	-3.6972×10^{-10}	0.0000	6.5133×10^{-13}	0.0000	-1.4221×10^{-16}
i=8	1.8007×10^{-13}	0.0000	-2.6076×10^{-16}	0.0000	2.1215×10^{-20}
i=10	-3.4325×10^{-17}	0.0000	4.1520×10^{-20}	0.0000	1.7302×10^{-24}

【００６４】次に、図１の第１の例に基づき、光源部１からの照明光ＩＬ１に加えて、光源部３Ａ，３Ｂからの照明光ＩＬ２Ａ，ＩＬ２Ｂにより投影光学系６のレンズ６１を照射した場合の計算結果を示す。なお、光源部３Ａ，３Ｂからの照明光ＩＬ２Ａ，ＩＬ２Ｂの照射領域は第１の例と少し異なっているが、効果の面では同様と考えてよい。

【００６５】図４（ａ）は、レンズ６１上の照射状態を示し、この図４（ａ）において、照明領域６２が内接する円内で照明領域６２に接する左右のほぼ半円形の照明領域６４Ａ，６４Ｂにそれぞれ照明光ＩＬ２Ａ，ＩＬ２Ｂが一様に照射されているとする。この場合、ウエハ７のフォトレジストを感光しない波長λ２の照明光ＩＬ２Ａ，ＩＬ２Ｂに対するレンズ６１の吸収エネルギー密度を照明領域６２における照明光ＩＬ１に対する吸収エネルギー密度と等しいものとする。

【００６６】図４（ｂ）は、以上の計算結果を図に表したものであり、この図４（ｂ）において、レンズ６１上の光軸ＡＸを中心とする同心円状の等温線６３Ｂに示すように、レンズ６１上ではほぼ回転対称に近い温度分布となっている。また、以上の計算結果に基づいて、上記（数６）によって、フーリエ・ベキ級数展開した級数B_{in}を計算した結果を表２に示す。

【００６７】

【表２】

	n=0	n=1	n=2	n=3	n=4
i=0	4.8298×10^{-1}	0.0000	1.7294×10^{-7}	0.0000	1.4426×10^{-9}
i=2	-3.0498×10^{-4}	0.0000	5.4971×10^{-9}	0.0000	-1.4191×10^{-11}
i=4	-2.5533×10^{-8}	0.0000	-1.8367×10^{-11}	0.0000	3.8396×10^{-14}
i=6	6.3606×10^{-11}	0.0000	2.5913×10^{-14}	0.0000	-4.7191×10^{-17}
i=8	-6.1809×10^{-14}	0.0000	-1.5972×10^{-17}	0.0000	2.6709×10^{-20}
i=10	2.0495×10^{-17}	0.0000	3.4875×10^{-21}	0.0000	-5.6051×10^{-24}

【００６８】図３（ｂ）及び図４（ｂ）のそれぞれの上昇後の温度分布を比較すると、図４（ｂ）の温度分布の方がかなり回転対称に近くなっている。更に、表１と表２とを比較した場合、ｉ＝０，ｎ＝０の場合の級数B_{00}、即ち光軸ＡＸ（ｒ＝０）での温度は、表２の場合の方が大きいにもかかわらず、それ以外の級数の絶対値は大体において表２の方が小さい。級数B_{in}の値のうち、ｎ＝０でｉ＝０以外の級数の値が小さいことは、照明光の照射による球面収差変動が小さいことを示し、ｎ＝０以外のｎ＝２やｎ＝４の級数B_{in}の値が小さいことは、照明光の照射による回転非対称な収差変動が小さいことを表す。即ち、図１の第１の例により、照明光の照射による中心アス等の回転非対称な収差変動が低減されることが分かる。

【００６９】次に、第２の計算例について説明する。この第２の計算例は図１に示す第１の例において、円弧状の照明領域を用いる場合の効果を具体的に数値で示すものである。先ず、比較のため、レチクル上の円弧状の照明領域だけに図１の照明光ＩＬ１が照射される場合について計算する。図５（ａ）は、投影光学系６のレンズ６１上の照明光ＩＬ１の照射状態を示し、この図５（ａ）において、レンズ６１は第１の計算例の長方形の照明領域６２（図３（ａ）参照）と同じ面積を有し、且つ同じ外接円を持つ円弧状の照明領域６５により照明されている。この照明領域６５は、投影光学系６の中心部のフレアを避けるために、光軸ＡＸからの距離が８．４ｍｍの円内の領域を含まないように形成されており、照明領域６５の中心６６は光軸ＡＸから所定の距離ｄの位置に設定されている。なお、照明光ＩＬ１のレンズ６１における照射エネルギー量は１Ｗである。その結果、円弧状の照明領域６５の２つのＹ方向の隅の点Ｌ３，Ｌ４（又は点Ｎ３，Ｎ４）を直線的に結ぶ距離ＤＲは１６．８ｍｍ、照明領域６５の２つのＸ方向の隅の点Ｌ４，Ｎ４（又は点Ｌ３，Ｎ３）を直線的に結ぶ距離ＤＳは７０ｍｍである。そして、光軸ＡＸから８．４ｍｍの円内の領域を避けるために、図５（ａ）の点Ｎ３，Ｌ３を結ぶ直線から照明領域６５の左側の円弧の接線との間のＸ方向の距離Ｓは２５．２ｍｍになるように設定されている。

【００７０】図５（ｂ）は、レンズ６１上の円弧状の照明領域６５だけが照明光ＩＬ１により照明されている場合のレンズ６１上の上昇後の温度分布を計算した結果を示し、この図５（ｂ）において、０．０２℃毎の等温線６３Ｃに示すように、温度分布は光軸ＡＸに対して右側に偏した非走査方向に長い楕円状の温度分布となる。この場合のフーリエ・ベキ級数展開した級数B_{in}を表３に示す。

【００７１】

【表３】

	n=0	n=1	n=2	n=3	n=4
i=0	1.6014×10^{-1}	6.3301×10^{-3}	3.3891×10^{-5}	-3.3261×10^{-6}	-6.5666×10^{-8}
i=2	-2.4216×10^{-5}	-1.0578×10^{-5}	-3.7951×10^{-7}	5.5797×10^{-9}	3.0172×10^{-10}
i=4	-2.8996×10^{-7}	4.9472×10^{-9}	7.4108×10^{-10}	-2.8098×10^{-12}	-4.5946×10^{-13}
i=6	3.6629×10^{-10}	2.0428×10^{-12}	-6.3917×10^{-13}	3.1792×10^{-17}	3.3061×10^{-16}
i=8	-2.0179×10^{-13}	-2.6958×10^{-15}	2.7273×10^{-16}	2.8736×10^{-19}	-1.1903×10^{-19}
i=10	4.2277×10^{-17}	6.8976×10^{-19}	-4.7047×10^{-20}	-4.0149×10^{-23}	1.7651×10^{-23}

【００７２】次に、図１（ａ）において、光源部１からの照明光ＩＬ１に加えて、光源部３Ａ，３Ｂからの照明光ＩＬ２Ａ，ＩＬ２Ｂによりレンズ６１を照射した場合の計算例を示す。図６（ａ）は、レンズ６１上の照射状態を示し、この図６（ａ）において、照明領域６５に接する左右の半円形の照明領域６７Ａ，６７Ｂにそれぞれ照明光ＩＬ２Ａ，ＩＬ２Ｂが一様に照射されているとする。この場合、上述のように、光源部３Ａ，３Ｂからの

照明光ＩＬ２Ａ，ＩＬ２Ｂの照明領域を円弧状の照明領域に合わせるように、光源部３Ａ，３Ｂ等を製作することは容易ではなく、本計算例においては、図６（ａ）に示すように、円弧状の照明領域６５の－Ｘ方向の頂点を結ぶ直線を一辺とする照明領域６７Ａと、円弧状の照明領域６５の右側の円弧の接線を一辺とする半円状の照明領域６７Ｂとに、それぞれ照明光ＩＬ２Ａ，ＩＬ２Ｂが照射されているものとする。そして、フォトレジストに感光しない波長λ２の照明光ＩＬ２Ａ，ＩＬ２Ｂによる照明領域６７Ａ，６７Ｂでのレンズ６１の吸収エネルギー密度を円弧状の照明領域６５における吸収エネルギー密度と等しいものとする。

【００７３】図６（ｂ）は、以上の条件での計算結果を図に表したものであり、この図６（ｂ）において、等温線６３Ｄで示す温度分布は図５（ｂ）の温度分布に比べて回転対称に近くなっている。また、以上の計算結果に基づいて、上記（数６）によって、フーリエ・ベキ級数展開した級数B_{in}を計算した結果を表４に示す。

【００７４】

【表４】

	n=0	n=1	n=2	n=3	n=4
i=0	3.2613×10^{-1}	1.9780×10^{-3}	1.8782×10^{-4}	-4.4163×10^{-6}	-1.4622×10^{-7}
i=2	-9.3395×10^{-6}	-9.7035×10^{-6}	-6.8352×10^{-7}	1.8846×10^{-8}	6.0409×10^{-10}
i=4	-4.7485×10^{-7}	1.9335×10^{-8}	1.1776×10^{-8}	-3.2278×10^{-11}	-9.7362×10^{-13}
i=6	5.3783×10^{-10}	-1.9862×10^{-11}	-1.0660×10^{-12}	2.8311×10^{-14}	7.7335×10^{-16}
i=8	-3.1285×10^{-13}	1.0210×10^{-14}	4.8154×10^{-16}	-1.2630×10^{-17}	-3.0439×10^{-19}
i=10	7.1741×10^{-17}	-2.0517×10^{-18}	-8.5698×10^{-20}	2.2606×10^{-21}	4.7624×10^{-23}

【００７５】表３及び表４を比較すると、光軸ＡＸにおける温度上昇を示す級数B_{00}以外の大部分の級数B_{in}の絶対値が、表４の値が表３の値より小さいとはいえず、図６（表４）の場合の方が大きな値の級数もかなりある。即ち、円弧状の照射領域の場合、図１に示す第１の例による方法では、レンズ６１上における温度分布の回転非対称性の改善の程度が小さく、回転非対称な収差変動の低減効果が小さい。従って、円弧状の露光領域の場合は、図２に示す実施の形態のように、光学フィルターによりウエハ上のフォトレジストを感光せず、且つ投影光学系６のレンズに吸収される波長の照明光による照明領域を円弧状の照明領域に隙間なく接するように設定すれば、投影光学系６のレンズ上の照射エネルギー分布の回転対称性が向上し、投影光学系の収差変動を低減できる。

【００７６】なお、本発明は走査露光型の投影露光装置に限らず、ステッパー方式等の一括露光型の投影露光装置で、レチクル上の回転非対称な領域のパターンをウエハ上に転写する場合にも同様に適用できる。このように、本発明は上述の実施の形態に限定されず、本発明の要旨を逸脱しない範囲で種々の構成を取り得る。

【００７７】

【発明の効果】本発明の第１の投影露光装置によれば、第１及び第２照明光は共に感光性基板上に照射されるが、第２照明光は感光性基板に対して非感光性であるため、第１照明光により照明されるマスク上の回転非対称な露光照明領域のパターンの像だけが感光性基板上の回転非対称な露光照明領域に転写される。また、第２照明光により第１照明光による回転非対称な露光照明領域を補完して、ほぼ回転対称な露光照明領域を通過した照明光により投影光学系を照明するため、投影光学系のレンズへの照射エネルギー分布の回転対称性が増加する。従って、回転非対称な熱エネルギーの分布によるレンズの熱変形や屈折率の回転非対称な分布が減少し、投影光学系の収差変動が少なくなる利点がある。

【００７８】また、本発明の第２の投影露光装置によれば、合成系により一旦合成された第１及び第２の照明光は視野絞りにより決定される領域をそれぞれ通過し、投影光学系を経て感光性基板上に照射される。第２照明光は感光性基板に対して非感光性であるため、第１照明光だけによる感光性基板上の被露光照明領域にマスク上のパターンの像が転写される。この場合、第１照明光は、視野絞りによりマスクの回転非対称な被露光照明領域としての第１の領域と共役な第１の透過部だけを通過するため、感光性基板上には、マスク上の第１の領域のパターンの像だけが転写される。一方、投影光学系には、マスク上の第１の領域を透過する第１照明光と、第１の領域を補完して実質的に回転対称な円形領域を形成するマスク上の第２の領域を透過する第２照明光とが入射する。第１及び第２照明光の全体の照射領域は実質的にほぼ回転対称な円形領域となるため、本発明の第１の投影露光装置と同様に、投影光学系のレンズへの照射エネルギー分布の回転対称性が増加して、投影光学系の収差変動が少なくなる利点がある。また、本発明ではマスク上の回転非対称な被露光照明領域に照射される第１照明光を整形するための光学系、及び第２照明光の照明領域を整形するための光学系が不要となる利点もある。

【００７９】また、本発明の第１及び第２の投影露光装

置において、第２照明光が照明する領域に位置するマスク上のマスクマークと第２照明光が照明する領域に位置する感光性基板上の基板マークとの少なくとも一方からの光を光電的に検出し、双方のマークの内の少なくとも一方のマークの位置を検出するマーク位置検出系を有する場合には、第２照明光をマスク又は感光性基板の位置を検出するためのアライメント用の照明光としても有効に利用できる利点がある。

【００８０】また、回転対称な所定の円形露光領域、又は回転対称な所定の円形領域と共役な感光性基板上の領域が、投影光学系の感光性基板側の視野と一致する場合には、投影光学系のレンズは回転対称で最大径のほぼ円形の照明領域により照明されるため、投影光学系のレンズへの照射エネルギーの分布の回転対称性が向上する利点がある。

【００８１】また、本発明の第３の投影露光装置によれば、感光性基板に対して感光性の照明光は、光制限部材によりマスク上の回転非対称な領域に対応する領域だけを通過して感光性基板上に照射される。従って、マスク上の回転非対称な領域のパターンの像だけが、感光性基板上に転写される。また、照明光によりマスク上のほぼ回転対称な領域を照明できるため、本発明の第１及び第２の投影露光装置と同様に、投影光学系のレンズへの照射エネルギー分布の回転対称性が増加する。本発明では、特に１つの照明光だけでマスクを照明するため、投影光学系のレンズ全体に一様な波長の光エネルギーが照射される。従って、投影光学系のレンズにおける熱エネルギーの吸収量もレンズ全体で一様になり、レンズの熱変形が更に減少し、投影光学系の収差変動も更に抑えられる利点がある。また、１つの照明光だけを使用するため、光源や照明光学系等の設備を節約できる利点もある。

【図面の簡単な説明】

【図１】（ａ）は本発明による投影露光装置の実施の形態の第１の例を示す概略構成図、（ｂ）は図１（ａ）のレチクル上での照明領域を示す図、（ｃ）は図１（ａ）のウエハ上での照明領域を示す図である。

【図２】（ａ）は本発明の実施の形態の第２の例を示す概略構成図、（ｂ）は図２（ａ）の視野絞りを示す平面図、（ｃ）は図２（ｂ）の視野絞りの変形例を示す平面図である。

【図３】（ａ）は図１の実施の形態による収差改善効果を示すための第１の計算例において、比較計算に使用されるレンズ上の照明領域を示す平面図、（ｂ）はそのレンズ上の上昇後の温度分布の計算結果を示す図である。

【図４】（ａ）はその第１の計算例において使用されるレンズ上の照明領域を示す平面図、（ｂ）はそのレンズ上の上昇後の温度分布の計算結果を示す図である。

【図５】（ａ）は図１の実施の形態の収差改善効果を示すための第２の計算例において、比較計算に使用されるレンズ上の照明領域を示す平面図、（ｂ）はそのレンズ上の上昇後の温度分布の計算結果を示す図である。

【図６】（ａ）はその第２の計算例において使用されるレンズ上の照明領域を示す平面図、（ｂ）はそのレンズ上の上昇後の温度分布の計算結果を示す図である。

【図７】本発明の実施の形態の第１の例の変形例を示す概略構成図である。

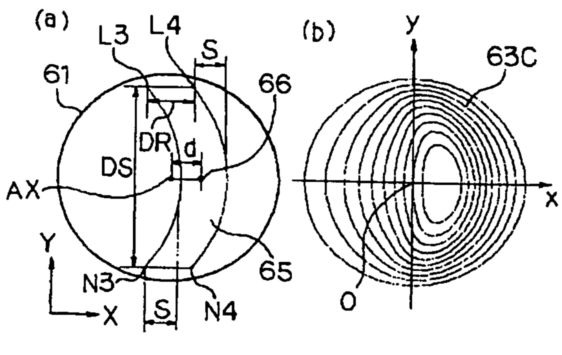
【図８】（ａ）は本発明の実施の形態の第３の例を示す概略構成図、（ｂ）は図８（ａ）の遮光板を示す平面図である。

【図９】（ａ）は図８の実施の形態の例において遮光板とウエハとの間に間隔がある場合の遮光板による照明光のケラレの状況を示す図、（ｂ）はその場合にレチクル又はレチクルと共役位置に配置する部材の例を示す図である。

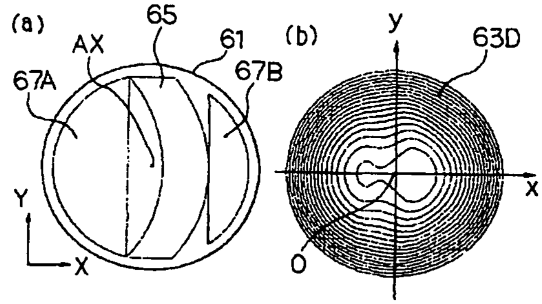
【符号の説明】

１　光源部（露光用）
２　照明光学系
３Ａ，３Ｂ　光源部（非露光用）
ＩＬ１　照明光（露光用）
ＩＬ２Ａ，ＩＬ２Ｂ　照明光（非露光用）
４　レチクル
６　投影光学系
７　ウエハ
８　ウエハステージ
１１Ａ，１１Ｂ　レチクルマーク
１２Ａ，１２Ｂ　ウエハマーク
１３Ａ，１３Ｂ　アライメントセンサ
１７，１７Ａ，１９，１９Ａ　レチクル上の照明領域（非露光領域）
１８　レチクル上の照明領域（露光領域）
２０　ウエハ上の有効露光領域
２１　ウエハ上の露光領域
２２，２３　ウエハ上の照明領域（非露光領域）
４２　偏光ビームスプリッタ
４３，４５　１／４波長板
４８，４８Ａ　視野絞り
４９，５０，５１，４９Ａ，５０Ａ，５１Ａ　光学フィルター
７１　遮光板
７３　透過領域

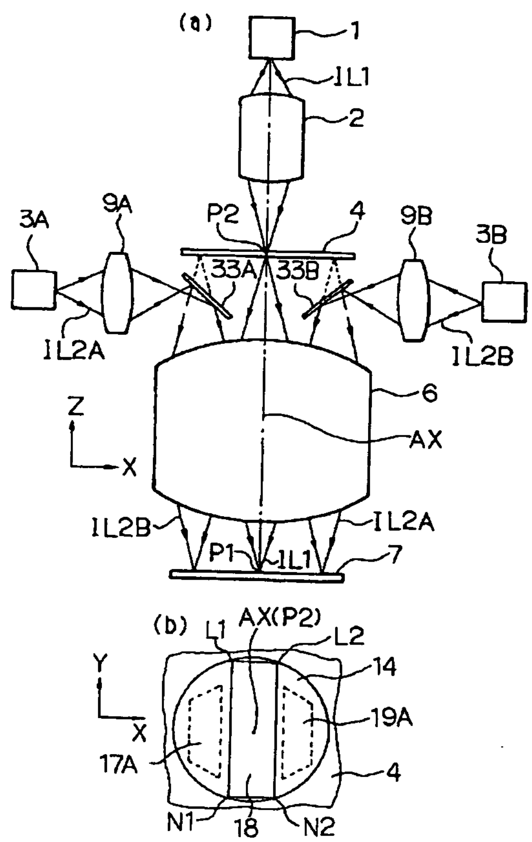
【図５】


(a)
L3
L4
S
61
66
DR
d
DS
AX
Y
X
N3
S
N4
65
(b)
y
63C
x
O

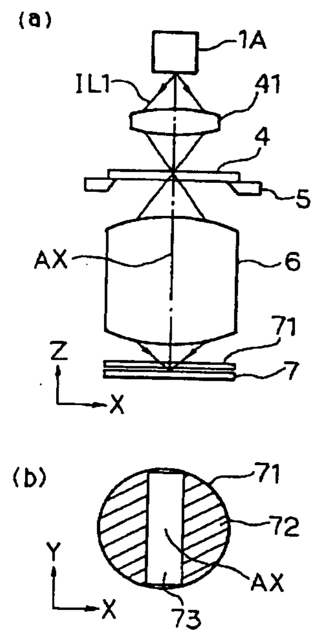
【図６】


(a)
65
AX
61
67A
67B
Y
X
(b)
y
63D
x
O

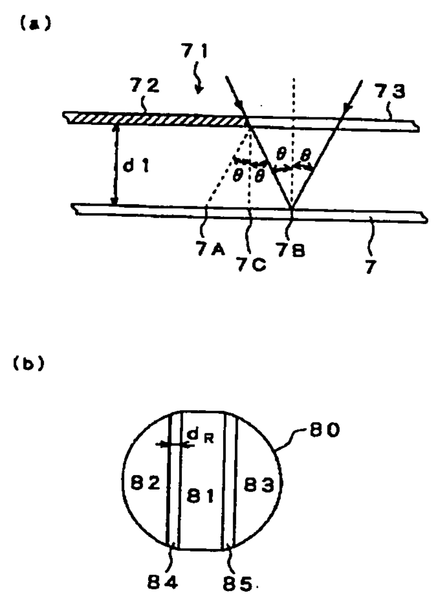
【図７】


(a)
1
IL1
2
3A
9A
P2
4
9B
3B
33A
33B
IL2A
IL2B
6
Z
X
AX
IL2B
IL2A
P1
IL1
7
(b)
L1
AX(P2)
L2
Y
X
14
19A
17A
4
N1
18
N2

【図８】


(a)
1A
IL1
41
4
5
AX
6
71
Z
X
7
(b)
71
72
Y
X
AX
73

【図９】


(a)
71
72
73
d1
θ
7A
7C
7B
7
(b)
dR
80
82
81
83
84
85